Bulletin No. 185 1928

The Cultivation of Lac in the Plains of India (*Laccifer lacca*, Kerr)

BY

RAI BAHADUR C. S. MISRA, B.A.
First Assistant to the Imperial Entomologist
Agricultural Research Institute, Pusa

(This Bulletin replaces Bulletin Nos. 28 and 142.)

CALCUTTA: GOVERNMENT OF INDIA
CENTRAL PUBLICATION BRANCH
1929

CONTENTS

LIST OF ILLUSTRATIONS.

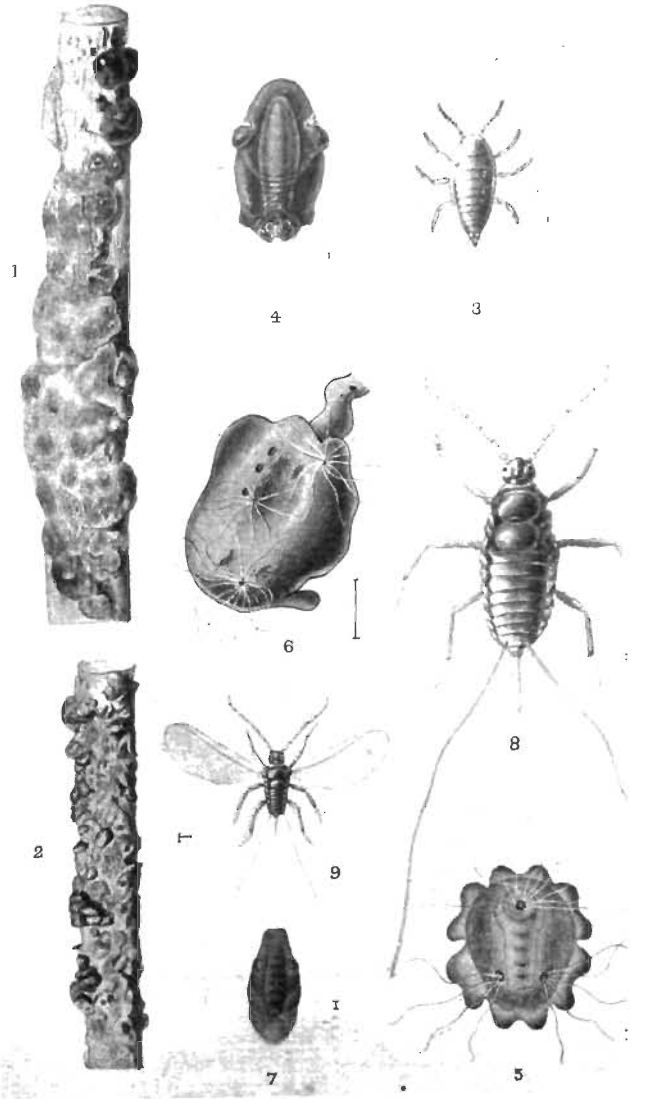
(A) PLATES.

(B) FIGURES.

(C) CHARTS.

(D) MAP.

PLATE I.



LACCIFERA LACCA.

The Cultivation of Lac in the Plains of India. (*Laccifer lacca*, Kerr.)

Received for publication on 1st May, 1928.

Introduction.

Lac is a resinous encrustation produced by an insect which sucks the juice of plants and transforms this juice into resin which completely surrounds it. This insect belongs to a group of insects called *Coccidæ* commonly known as Scale Insects. It is found growing spontaneously on a large number of trees, but is especially grown on the Kusum (*Schleichera trijuga*), Palas (*Butea frondosa*), Ber (*Zizyphus jujuba*), Pipal (*Ficus religiosa*), Siris (*Albizzia lebbek*), Ghoont Ber (*Zizyphus xylopyra*), Babul (*Acacia arabica*), *Pithecolobium saman* and Jalla (*Shorea talura*).

From ancient history it is known that lac has been cultivated in India since very remote times. The very name of *palas* (*Butea frondosa*), *Laksha-taru*, shows that the ancient people of India knew the tree to nourish a *laksha*—one hundred thousand insects. From ancient literature it is also evident that the Rishis of India prohibited the use of such *Laksha-taru* twigs as had small scarlet excrescences on them —possibly the lac encrustations. In the *Mahabharat* in the *Adi-Parva* when the Kauravas meditated destruction of the Pandavas they requisitioned the services of the architect Purochak to construct such a house which would destroy them. Purochak, therefore, decided to build a house of lac which when once ignited would soon catch fire and prevent the Pandavas from escaping. Early in 250 A.D., Ælian mentioned that there was an insect in India which yielded colouring matter. We also find lac mentioned in *Ain-i-akbari*. In 1590, Akbar, the Great Moghal Emperor, laid down rules for the proper making of varnish to be applied to the doors of palaces. We have the first descriptive account of the resin from John Huyglen von Linschoten when he was deputed in 1596, by the King of Portugal, on a scientific mission to the East Indies. Abu Hanifa also mentions it and recommends its use as a medicinal thing. In 1781 Dr. Kerr in the *Philosophical Transactions*, Vol. LXX, p. 574, was the first to describe the lac insect. Nine years later in 1790 Dr. Roxburgh in the *Asiatic Researches*, Vol. II, pp. 360-366, gave a detailed account of the life-history of the lac insect. Ten years later

Dr. Buchanan-Hamilton was the first to publish a detailed account of the propagation and cultivation of lac in India, and three decades after Dr. Carter in 1861 gave an account of the internal anatomy of the insect and this account was reproduced by Mr. J. E. O'Conor in his *Note on Lac Production, Manufacture and Trade.* Of late a large amount of literature has appeared, but this relates to lac either grown or collected in the forests. There is very little comprehensive information regarding the industry as pursued in the Plains of India, and from what I have seen there are reasons to believe that this aspect of the industry is very widespread in the Plains and provides means of subsistence to thousands, if not millions, of the poor illiterate masses—especially the aborigines who inhabit the outskirts of forests or the interior of districts where the host-plants of the lac insect abound. The information regarding cultivation in the Plains lies scattered in the District Gazetteers or the Revenue Reports which are practically inaccessible to the public. But for all this, the industry is very important to an agricultural country like India, where, I know from personal observations, it forms an important adjunct to agriculture and as such helps the cultivators in such areas to tide over financial stress at a time when rates are low and climatic conditions are against them in disposing of their produce in the market. That the cultivation is widespread and important is evident from the export figures of shellac from the port of Calcutta alone. As I have already pointed out in my article on "*The Present Condition of Lac Cultivation in the Plains of India*" (*Agri. Jour., India*, Vol. XIII, Part III, July 1918) the exports of shellac from the port of Calcutta only have been as follows during the past 21 years :—

Year	Cases	Weight in maunds (80 lb.)	Price per maund	Total value
			Rs.	Rs.
1905	157,536	315,072	87	2,74,11,264
1906	156,502	313,004	107	3,34,91,428
1907	206,789	413,578	102	4,21,84,956
1908	222,112	444,224	57	2,53,20,768
1909	322,006	644,012	37	2,38,28,444
1910	289,996	579,992	40	2,31,99,680
1911	235,339	470,678	37	1,74,15,086

Year	Cases	Weight in maunds (80 lb.)	Price per maund	Total value
			Rs.	Rs.
1912	254,141	508,282	34	1,72,81,588
1913	191,993	383,986	46	1,76,63,356
1914	231,831	463,662	35	1,62,28,170
1915	243,502	487,004	34	1,65,58,136
1916	236,681	473,362	55	2,60,34,910
1917	194,348	388,696	118	4,58,66,128
1918	197,066	384,132	193	7,41,37,476
1919	208,567	417,134	197	8,21,75,398
1920	218,313	436,626	360	15,71,85,360
1921	233,284	466,568	175	8,16,49,400
1922	248,114	496,228	185	9,18,02,180
1923	303,919	607,838	171	10,39,40,298
1924	236,704	473,408	158	7,47,98,464
1925	275,033	550,066	134	7,37,08,844

The above calculations have been made on the basis of a case to contain two maunds of shellac. *The prices have been calculated on the basis 1s. 4d. to the rupee* on the average price of the year for T. N. in shillings per cwt. in London market, as per Messrs. Moran & Co.'s Shellac Statistics for the years 1906-1921, Calcutta.

Thus on an average over 450 thousand maunds of shellac worth over 4 crores of rupees had been sent out yearly from the port of Calcutta only in the past. The figures of exports from the ports of Bombay and Karachi are not available. If these were available it would have been seen that over 500 thousand maunds of shellac, worth over 5 crores of rupees, are sent out of the country. To produce so much shellac annually at least 40 millions lb. of sticklac must be utilized. If, to this be added the internal consumption, which is by no means small, it would be found that the total yearly produce of sticklac must be not less than 50 to 60 millions lb., and if we take the yearly average individual production to be 80 lb. at least 750,000 persons must be deriving their subsistence from the industries, besides a horde of manufacturers, brokers, salesmen, shippers, wharfmen, etc., the numbers of persons directly or indirectly

benefited by the industry will be found to be very large indeed. But in spite of all this, nothing has been done in the past to resuscitate the industry and put it on a sound basis. There is still an element of uncertainty in the whole business which at the present time is more or less of a speculative nature and thus deters a large number of persons going in for it. There is a very trite Hindi saying "*Lakh nahin to' khak*," aptly illustrating the speculative nature of the industry. And the wonder is that with all the uncertainties of a precarious crop and ever-shifting market, the industry has been able to hold its own against various circumventing factors which at various times seemed to engulf the industry and reduce it to the same status as a once-flourishing Indian industry has been reduced to now-a-days. What and in what direction this vitality has lain is known to those who have paid any attention to the industry for some time. There are years of depression as well as inflation, but with all this the industry has existed and is likely to exist for some time to come. Whether this will continue for ever only futurity can decide. But if proper measures will be taken to safeguard the industry even so late as now, the possibility of the disturbing factors operating early will at least be avoided or indefinitely postponed. The industry has of late assumed a very precarious aspect. Hundreds are benefited suddenly, whilst equal numbers, if not more, are more or less affected adversely annually. So great is the element of uncertainty that few dare to risk their money either in cultivation or in manufacture, and the fact is borne out by the low prices prior to the breaking out of the last great war when the minimum of Rs. 23 per maund of shellac was touched. During the last great war fresh uses were found for the commodity and prices rose by leaps and bounds, so much so, that the maximum of Rs. 285 per maund was touched for a few days. There was a general scramble; the cultivator as well as the manufacturer was anxious to make the most of the temporary swell in prices. The former went hunting every nook and corner of the lac-producing areas and, I am told, in particular lac-growing tracts so great was the rush that even fairly large-sized trees were cut down for the sake of a few *seers* of lac on them. But from what I have been able to gather, the cultivator was not much better off than he was before. He got some but not the amount commensurate with the labour and risks incurred by him.

Hitherto the cultivation has been confined to India, Burma and to some extent Indo-China, Annam and Cambodia. Specimens of lac on *Covillea glutinosa* (formerly *Barrea mexicana*) are also found in the United States of America and Mexico (Fig. 1) but the majority of the world's demand is met with from India. Recently attempts

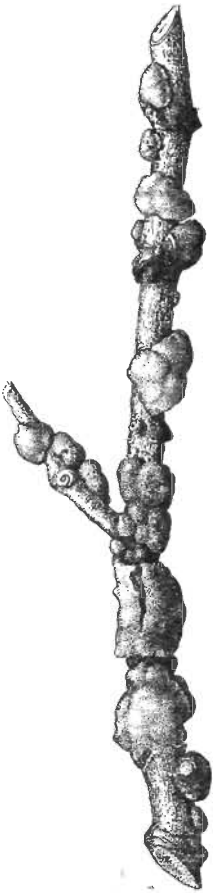


FIG. 1. *Tachardiella larreæ*, Comst on *Covillea glutinosa* in South-Western portion of the United States and Mexico. (Original.)

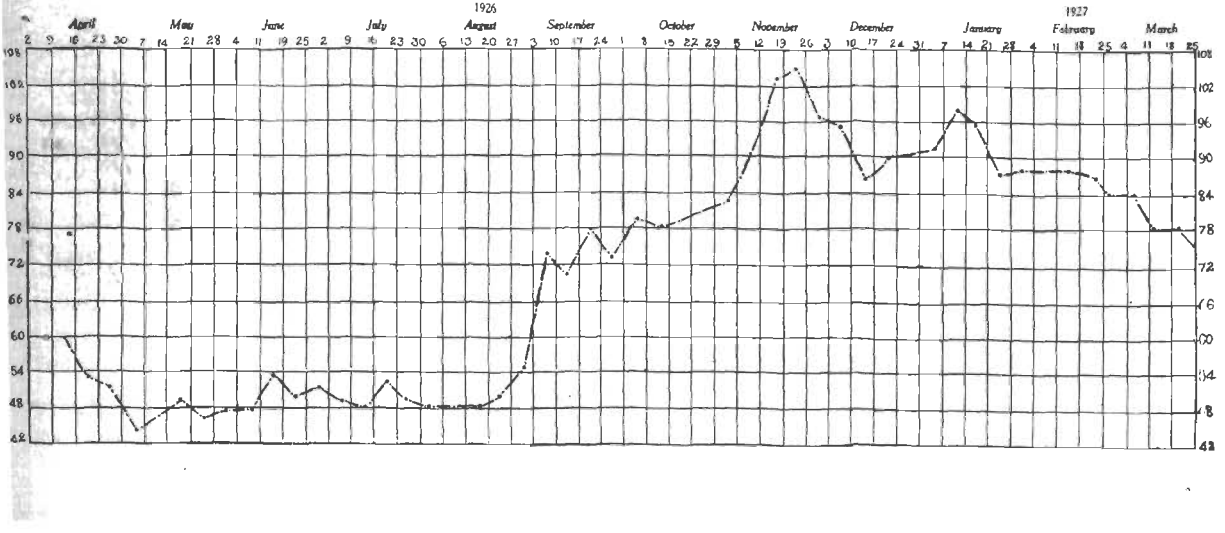
were either made or are being made to grow lac in Formosa by the Japanese on *S. trijuga*, a tree which grows in numbers there as a shade tree to camphor trees, by the Germans at Amani in South-East Africa, and to some extent in Egypt. That the industry is an important one in Indo-China (Tonkin, etc.) is shown by the fact that a detailed account of cultivation, refinement and manufacture of lac is given in *Bulletin Economique de L'Indo Chine*, No. 116, November-December 1915, pp. 872-944. Here the methods of refinement are very much like those adopted in this country, excepting that a wider use is made of the essences obtained from the by-products of lac. The writer in the bulletin quoted above has summarized the industry in Tonkin and has largely drawn upon the Lac Bulletin issued by me in 1912. The processes of refinement in that country appear to be the same as those adopted in this country, and it is rather strange to see that the methods of manufacturing shellac adopted in that country are as antiquated as those adopted in this country and seem to be a copy of those adopted in this country from times remote. Exports of stick-lac from Bangkok and Singapore, which had shown a considerable advance recently, decreased heavily in 1926, owing to a falling off in the demand from the United States and consequent low prices.*

Besides the lac produced in India, there is another kind of resin produced in Madagascar by *Gascardia madagascarensis*, Targioni-Tozzetti (Tar. Tozzetti, p. 425, 1894). This fact was first brought into prominence by M. A. Gascard in 1893 (*Contribution a l'etude des Gommes Laques des Indes et de Madagascar, D'edit. Sci. Paris*, also *Bull. Soc. Ent. Italy*, Vol. XXVI, pp. 457-464, 1894). But the insect producing this differs considerably from that producing lac in structural details.

Lac was first sought after when the prices of cochineal rose high. As is known cochineal is used for dyeing silk and is still used for giving those delicate shades to silk which cannot be done with synthetic dyes. In the beginning, lac met with the same fate as tea, where the decoction was thrown away and the boiled leaves were used for chewing. In this case the resin was not utilized commercially and was considered a waste product in much the same light as lac-dye has come to be considered now-a-days. From 1814 lac-dye began to be exported in increasing quantities. The maximum was reached in the years 1822, 1824 and 1826 when 760,729 lbs. were exported. The export began to decline rapidly from 1882-1883 until it became practically extinct in 1896-1897. In 1900 the total quantity of lac-dye exported was only a ton. Corresponding to this decrease, the resin in the form of shellac has been rising

* Review of the trade of India, 1926-27, p. 91.

Chart 1.—Showing prices of Shellac (T. N.) per md. Calcutta.



continuously. The figures for the twenty-one years 1905-1925 have been already given above.

From these figures it will be seen that in 1921 over 36 million lb. of shellac worth 8,16,49,400 rupees were exported from the port of Calcutta only. Had such figures been available for the other Indian ports, Bombay, Madras and Karachi, it would be safe to reckon the total production together with the internal consumption to be not less than 60 million lb. of shellac. To produce this quantity of shellac, 150 to 160 million pounds of crude lac must be produced yearly to meet the increasing demand, and as fresh uses are being found every year there is every likelihood of the consumption being increased. But with increased consumption the prices are bound to rise and if these go beyond a certain limit, as was the case with cochineal, the attention of the consumers is bound to be attracted to a cheap substitute.

Hitherto the lion's share of the profits has gone to the middlemen, factors which contribute very little to the resuscitation of the industry and amelioration of the condition of the poor, illiterate cultivators who in some localities, risk their lives for the sake of a few lb. of the crude material. During the last war the prices of a maund (82 lb.) of shellac touched their highest watermark of Rs. 285 per maund, the only visible increase obtained by the cultivators in remote corners of regions producing lac was only an increase of two to five annas only. Prior to the breaking out of the last great war, the prices had touched their lowest, *i.e.*, Rs. 23 to Rs. 32 per maund, and by the end of the war they had gone up as high as Rs. 285 a maund. With an improvement of over 1,200 per cent. on the manufacturer's side the improvement on the cultivator's side has been less than 50 per cent. even. This is a wide gap to be reconciled and I do not think it is possible to effect any appreciable changes in the near future. The machinery at present operating has been in existence since time immemorial and it will be hard, if not impossible, for any industrial reformer, private or official, to effect any appreciable change within the span of his official life.

The prices of T. N. touched their bottom in October 1914 and this state of affairs continued until July 1915, when the prices began to rise reaching their maximum in February 1920, when they again began to decline reaching the minimum in September 1925. As the following June-July crop was poor and as the supply of broodlac became limited during October-November 1926, the rates began to rise and reached the maximum during the latter part of November 1927 (see Chart I). With the fall in prices, as was the case from 1909 until July 1916, and again from October 1925 to August 1927 the interest flags, and the attention of the cultivators and others interested in the develop-

ment of lac cultivation is directed to other sources of income. In some cases I have seen that forests stocked with good sized lac bearing trees were leased out for the collection of fuel. Now with an improvement in shellac prices, attempts are being again made in such forests to utilize them for lac production. But it is not borne in mind that fitful attempts do not stabilize the industry. The rates prevailing now cannot be expected to remain constant for long, and in my opinion, such rates do more harm than good. With high prices, the attention of consumers is directed to finding out a cheap substitute* and if some such is found, the whole industry will meet with the same fate as indigo. If, however, the price of T. N. is standardized at Rs. 60 per maund (80 lb.) in the Calcutta market, the prices of stick-lac would automatically become fixed, and would leave an ample margin to the cultivator in the rural areas, considering the cost of cultivation to have gone up from Rs. 10 to Rs. 15 a maund.

In his review of the trade of India, for 1926-27, the Director General of Commercial Intelligence remarks that the use of synthetic lacquers, though growing in importance, has not as yet appreciably affected the trade in Indian shellac. The enormous increase in the demand for automobiles and for nitro-cellulose lacquers (which use a small amount of natural shellac) has helped to maintain the demand for shellac.

At present the maximum production and collection of lac takes place in the area extending from Chhatarpur in the North to Goona, Bhopal, Bhusaval, Chanda (including the north-eastern portion of the Nizam's Dominions), Parvatipuram, Bankura, Azimganj, Malda, Gaya, Ahraura (Mirzapur District, United Provinces), Rewah and thence to Panna. Besides this, considerable quantities of stick-lac are also collected in Sind, Assam and Burma (Plate II). Local collections are also made in the Punjab, the United Provinces, parts of Central India and Mysore in the South, and if sustained efforts were made and continued in these areas, the produce could easily be increased, if not actually doubled. In other parts the host plants of the lac insects are present in abundance, but the climatic conditions and the absence of a sufficient and regular supply of brood-lac, are a serious bar to the extension of cultivation in these areas. If, however, regular plantations of *palas* and *ber* are started from now, and steps are taken to prevent such plantations being injured by hot winds by planting protective rings of some such fast-growing trees as *Pongamia glabra*, etc., such areas could be made to yield a regular income commensurate with the time and money spent upon developing

*Review of the trade of India for 1926-27, p. 90.

them. In some places, owing to the prevalence of favourable shellac rates, people in the Northern parts of the Central Provinces have started lac cultivation on a regular system, and on one such *palas* plantation that I visited, I was informed by the proprietor thereof that he was able to obtain a produce of six maunds per acre. The estimate of the produce given out, though high, still it could be said that the proprietor was amply compensated for his investment and labour in developing the estate. A similar thing has also happened in the past in one of the districts of Bengal. Here the *ber* trees are grown on the field embankments. A cultivator generally has from 10 to 15 trees on his land, and from these he is able to get an average of two maunds, which he is able to sell for Rs. 50 to Rs. 60 according to the rate prevailing in the market. The recent high prices of shellac have stimulated cultivation on these lines, and the cultivators of such areas are much better off than their neighbours where no lac is grown. So successful was lac cultivation in this area that, during May and June 1920, a controversy was started in the districts of Malda and Murshidabad in Bengal that the lac insects on the trees were the source of infection of pebrine in mulberry silkworms, *Bombyx mori*. An exhaustive inquiry was conducted in the area and it was found that the controversy was due more or less to economic causes. The cultivators, who were growing lac on *ber* trees round their homesteads, were also rearing silkworms in their cottages. But with the rise in the price of shellac, they found lac to pay them more than silkworms and the consequence was that they either gave up or restricted their silkworm rearings and extended their lac cultivation. The persons interested in silk took up the cry and persisted in fresh investigations being made as to the truth of the complaint. Brood-lac was obtained from the infected locality and put on to *ber* (*Zizyphus jujuba*) trees at Pusa. A few healthy *ber* trees were inoculated with healthy *ber* brood-lac from Pusa and when the lac larvæ had established themselves well and had begun to develop, they were infected with pebrine cultures, supplied by the Protozoologist, Pusa. Specimens from both the plantations were examined by the Protozoologist and were found to harbour no pebrine bodies; the adult gravid females were, however, at times found to be full of yeast bodies. With the declaration of these results, the controversy was at last set at rest.

At present, India holds the monopoly of this commodity, although attempts have been made in the past and are still being made to grow lac in Egypt, Uganda, the Transvaal, Formosa and South-West China from brood-lac obtained from this country. Some lac is also collected in Sikkim, which finds its way into this country through the principal markets situated at the foot of the Himalayas. Sikkim and Nepalese

brands of lac are put up for sale in the form of coagulated discs at Bageswar in the Kumaon Hills (Fig. 2). Some lac is also found in

Fig. 2 Lac cakes from Nepal. (Original).

Kashmir, on Khair (*Acacia catechu*) and efforts are now being made by the State Forest Department to extend the cultivation in the State Forests, especially towards Billawar side. Bhutan and a part of Tibet lac finds its way to Rangiya in Assam. Indo-China and Siam also grow lac, but the total yearly output is not more than 2-3 per cent. of the whole yearly outturn. The majority of this lac finds its way to France where it is utilized for the low grade varnishes. It does not bleach well and is unfit for the manufacture of T. N. and other standard grades of orange shellac. Exports of stick-lac from Bangkok and Singapore, which had advanced considerably during recent years, decreased heavily during 1926 owing to a falling off on the demand from the United States.

Distribution of supplies of lac products.

The largest quantity of shellac manufactured in the country finds its way to the United States of America where it is mostly used for the manufacture of gramophone records and in electrical works. About 42 per cent. of the total quantity exported finds its way to the United States of America. About 26·8 per cent. goes to the United Kingdom. Prior to the last war, Germany stood third on the list of consumers, inclusive of re-exports to Russia and Scandinavia. She went in especially for the low grades of shellac for the manufacture of cheap varnishes which again found their way into this country. France stands fourth, Holland fifth and then follow Austria-Hungary, Japan, Italy, Belgium and Australia in the order of their consuming capacity. No statistics are available for internal consumption, but it is thought that it is not inconsiderable, though the uses to which lac is put locally are very limited. During 1926-27, shipments of shellac rose from 417,000 cwt. to 425,000 cwt. but decreased in value from Rs. 5,76 lakhs to Rs. 4,32 lakhs. The United States of America took 239,500 cwt. as against 226,800 cwt. in the previous year. The shipments to the United Kingdom increased from 82,700 to 86,900 cwt. The shipments to Germany and Belgium increased from 32,800 cwt. and 3,200 cwt. to 35,200 cwt. and 3,900 cwt. respectively—though Japan, France and Italy reduced their purchases.

A considerable decrease took place in the exports of sticklac during 1926-27—though shipments of seedlac increased from 37,400 cwt. to 89,400 cwt. If this increase is maintained, shipments of shellac are likely to shrink in the future.

Trees on which lac is grown.

Ber. The *ber* is a very hardy tree and grows well in poor soils. It stands pruning well and within a short time sends forth a sufficient number of vigorous, succulent branches to nourish the lac insect. With judicious pruning the tree could be made to yield a crop annually. In the Jangipur Sub-division of the Murshidabad District in Bengal, the trees are grown on rice field embankments, and are annually pruned carefully for propagating the lac insect. The cultivator either uses the brood-lac from his own trees or buys it locally in the *hats* where a *tudie* of 50 sticks, each 10 to 11 inches long, was to be had from annas twelve to a rupee each. The cultivators in this tract are very careful in pollarding their trees, and occasionally bring fresh seed-from Dumka or other places in the neighbouring hilly tracts. Some such practice also prevails in the Kolhan in the Singbhum District, where the *Kol* grows a few trees round his hut, prunes them carefully during January and inoculates them with brood-lac obtained locally. In the Una Tahsil of the Hoshiarpur District in the Punjab, a sufficient quantity of lac is grown on the *ber* trees planted on the roadsides. Here no pollarding is done, but the removal of the crop serves the purpose of pollarding. The produce from the area either goes to Amritsar or to Mirzapur where it is utilized for shellac making. There is considerable scope of extending cultivation on *ber* in the Kolhan as the trees are present and the *Kol* knows well

how to grow the insect and keep watch over it when it matures. At Pusa, successive crops have been raised on the tree for the past sixteen years with proper pollarding and giving rest to the trees at intervals. The trees thus utilized do not show any signs of deterioration, and with a system of well adjusted rotation are as healthy as they were in the beginning. In the Punjab, the United Provinces and Central India, the tree is grown for its fruits, but if any tree becomes self-inoculated, the crop is gathered and sold locally to the bangle-makers. Owing to the prevalence of high prices of shellac at present, people have begun starting regular plantations of this tree. If these are worked systematically on scientific lines, there is every possibility of increasing the output of sticklac and preventing thefts. The tree grows well from seedlings which should be planted out when they are a year old in pits especially dug out for the purpose in the beginning of the rains. In starting plantations of *ber*, pits 2 feet 6 inches in diameter as well as in depth should be dug out in the beginning of April. The earth from the lower surface should be kept separate from the surface soil. It should be well aërated and then turned into the pit by the end of the month. Well rotted cow-dung manure should be mixed with the surface soil and turned into the pit. The surface of the soil should be a little above the ground level to allow for the sinking of the soil during the rainy season. *Ber* fruits from healthy trees with a good crown should be collected during March-April and dried in

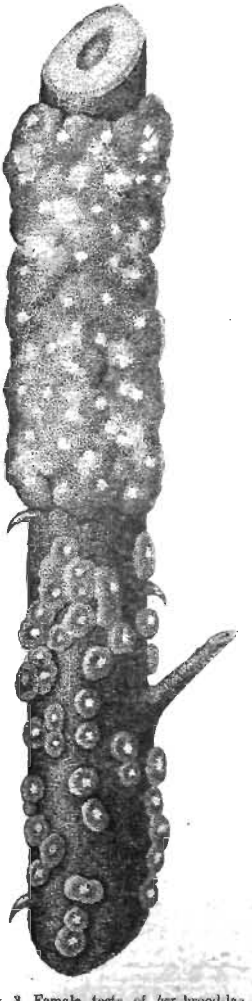
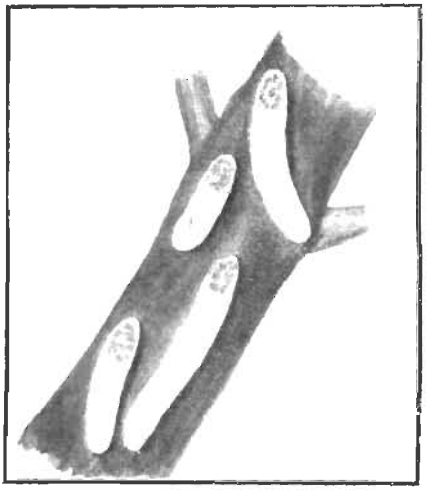


Fig. 3. Female tests of *ber* brood-lac at the time of swarming out of larvæ Pusa, 8th July 1923. (Original).

* *Review of the trade of India* in 1926-27, p. 90.

PLATE III.



1. *Pulvinaria* sp. on *ber*.—Mathurapur, Bengal. (Original.)

2. *Chionaspis* sp. on *ber*.—Mathurapur, Bengal. (Original.)

the sun. The pits should be watered, and after four or five days the surface should be broken and the soil mulched to a fine consistency when three, healthy, round, uniform sized *ber* seeds, previously cracked with a hammer to insure an early, uniform germination, should be sown in each pit. When the seedlings come out they should be protected from the attack of *Chrotogonus* spp., which nibble off the cauline leaves. This is done by piling two tiles together by their edges. During the rains the soil on the pits is to be constantly stirred and the drainage attended to. If a large area is to be put under *ber*, *Crotalaria juncea* (*sann hemp*) may be sown between the pits and when the plants are 2 ft. 6 inches to 3 feet they should be rolled down and ploughed into the soil. This enriches the soil and makes it more retentive of moisture, as well as, affords shelter to the seedlings against the surface Grasshoppers, *Chrotogonus* spp. and other obnoxious insects in the early stages of their growth. In localities where *ber* seedlings are available, these may be dug out of the ground and their root system carefully pruned with a sharp knife to a depth of 9 inches and the stems above ground reduced to 6—8 inches. Such stocks if planted into the pits on a cloudy day in June when there have been two or three good showers to wet the ground thoroughly strike roots early. Such roots, if the earth round them is carefully pressed at the time of transplanting, strike roots readily and grow up into vigorous trees fit to be inoculated 4-5 years after they have been put into the pits permanently. Casualties in the plantation should be replaced with uniform sized, vigorously growing seedlings from the nursery. In planting a few trees round homesteads, with a view to extend and encourage the cultivation of lac as a cottage industry, the pits should be filled in with well rotted compost or home sweepings, if cowdung manure is not available. The soil round the pits should be kept clear of weeds and frequently stirred to increase soil aëration. A few *Lycaenidæ* (Blue-butterflies), a *Tingid* Bug, a leaf-miner (*Bucculatrix zizyphella*, Chrétien. *Pulvinaria* sp. (Plate III-1) and *Chionaspis* sp. (Plate III-2) are bad in the early stages of the growth of the plants, but if a careful watch is kept for these, not much damage is likely to be caused to the plants. Ten to twelve years, and in some places five to six years after planting, the trees could be inoculated with lac. In a few places, it has been found that the sedlings are damaged by a borer which makes unsightly tunnels on the stems and branches covered over with brownish silken floss freely interspersed with pellets of its excreta. The borer *Indarbela tetraonis* has a wide range of foodplants. It is found to bore into litchi, *sissu* (*Dalbergia sissu*), *siris* (*Albizzia lebbek*), Indian laburnum (*Cassia fistula*), *Citrus* trees, mango, *jamun* (*Eugenia*

jamboluna), *aonla* (*Phyllanthus emblica*), *mahua* (*Bassia latifolia*) and even the thick stems of *menhdi* (*Lawsonia alba*) (Fig. 4). Besides this, a few other insects, mostly leaf-rollers, *Ancylis lutescens*, Meyr., *A. cyanostoma*, Meyr., *Epiblema* sp., and *Porthmologa paraclina*, Meyr. The larvæ of these roll up the leaves and remain feeding within the rolled-up leaves. A mite, recently identified as *Phytoptipalpus transitans*. Ewing, produces numerous pustules on the tender bark of seedlings, as well as pollarded trees. In old, unpollarded trees, these pustules coalesce and cause roughening of the bark. In some cases it has been observed that these pustules, if numerous, obstruct the establishment of lac larvæ. If these pustules be opened with a knife, small bright red mites in all stages of development will be found within them.

In the Central Provinces (Fig. 5) as well as in the Chhota Nagpur plateau, lac growers generally put *kusum* broodlac on *ber* but not *vice-versâ*. But at times it has been observed that even *kusum* broodlac when put on four-year old *ber* plants in the beginning of August, suffers heavily from the effects of *Eublemma amabilis* and the parasitic *Chalcididæ*; so much so, that in one locality the crop was wiped out entirely before it had matured. The same practice also prevails in the Bankura District, Bengal, especially the Khatra Sub-division, where lac-growers have a *palas* plantation forgrowing lac and ultimately utilize it for putting on to *ber* trees, as they think that lac from *ber* trees is superior in quality to that produced on the *palas* trees. Here the lac-growers think that when *ber* broodlac is put on to *palas* trees it fails to reproduce itself satisfactorily. The lac-growers generally plant a number of trees round their huts and obtain a crop yearly in September and October which they call *Rangeen*. The *ber* trees are pollarded carefully in the beginning of June every year and inoculated with *palas* brood-lac in October-November. At Pusa successive crops have been obtained from *ber* trees by pollarding them carefully and utilizing *ber* brood-lac for inoculating the pollarded trees. By ca.eful selection and elimination of *Eublemma*-infested brood-lac sticks heavy crops have been obtained from the trees without damaging their vitality in the least (Text-fig. 3). It has also been found by experience that the quality of *ber* fruits does not depreciate to any great extent, as is generally supposed.

Palas The *palas* grows wild over a large area in Bengal, the United Provinces, Bihar and Orissa, the Central Provinces, Central India, Sind, the Punjab: and some parts of the Bombay Presidency. It grows luxuriantly in poor soils and does not require much care. Hitherto it has been allowed to run wild for the sake of the fuel, but now with a rise in the price of shellac, attention is being drawn to growing it syste-

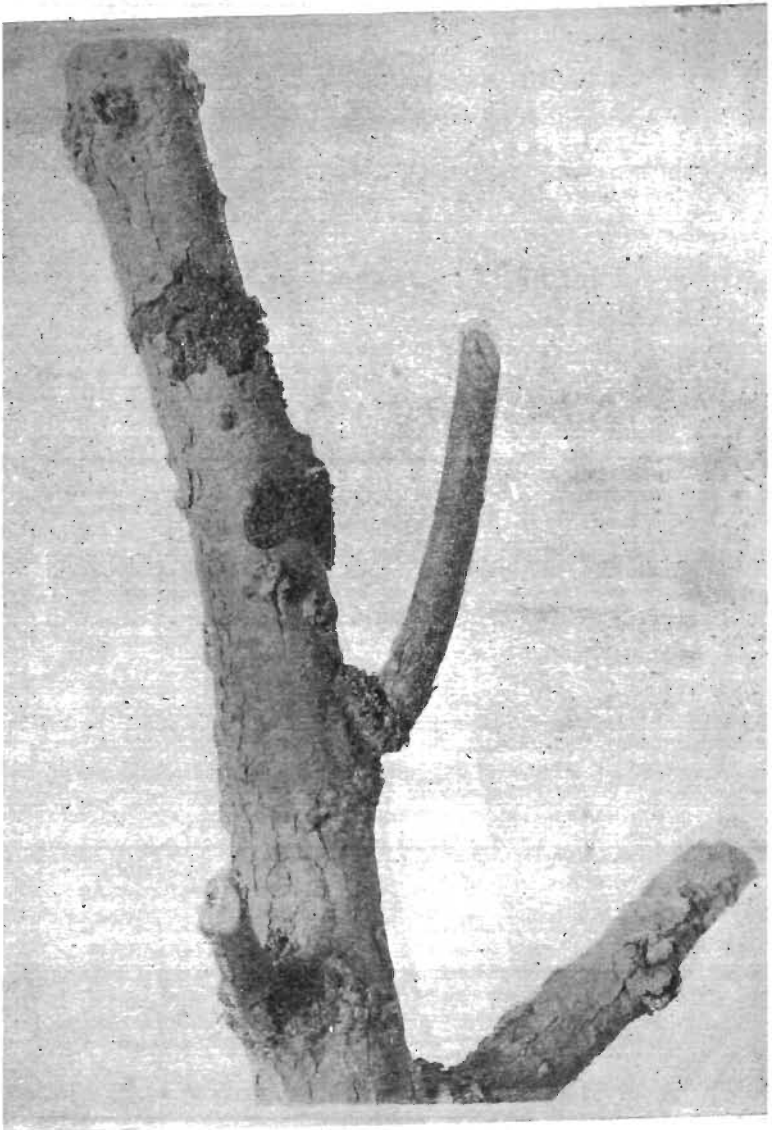


FIG. d. *Indarbela tetraonis*, boring into a *ber* branch. (Original.)

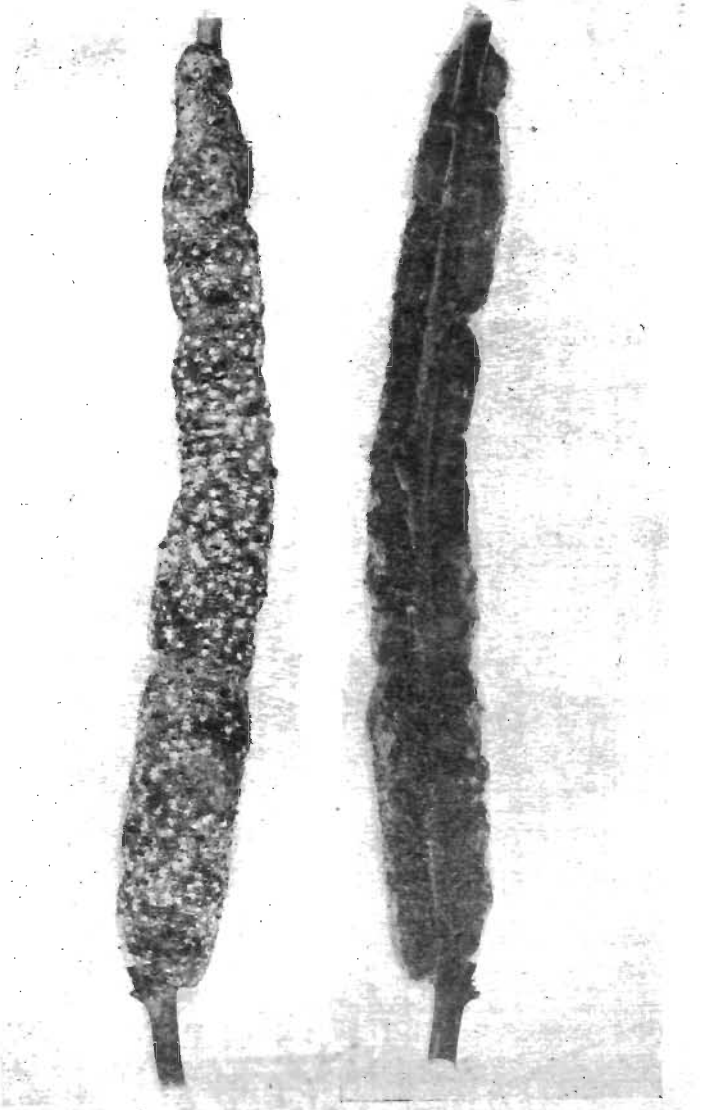


Fig. 5. *Kusum* broodlac on *palas*,—Dokal Range—South Forest Division, Raipur, C. P. (July 1922). (Original.)

matically in squares or blocks, and to utilize these for the propagation of the lac insect. If carefully pollarded, it sends forth sufficient suc-

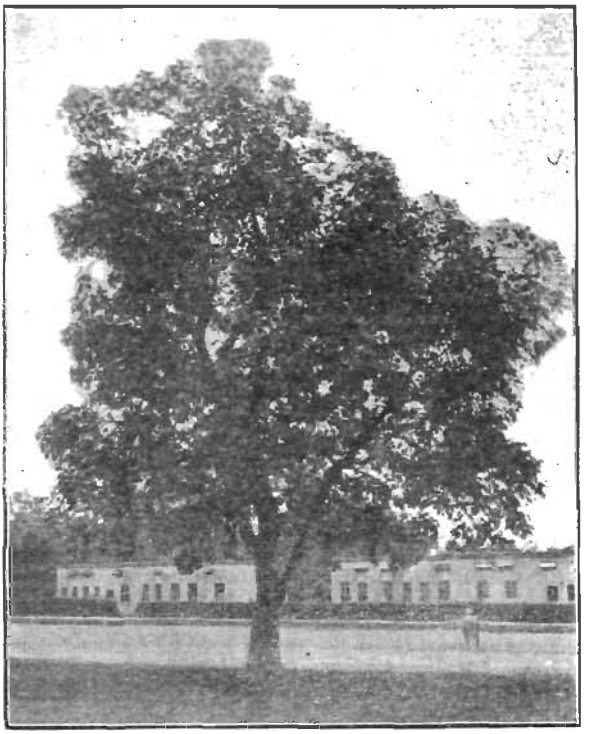


FIG. 6. A *palas* tree on loam soil eighteen years old.—Agricultural Research Institute grounds, Pusa. (Original.)

culent shoots to propagate the lac insect. The tree can be raised from seed as it does not transplant well. The seeds should be dibbled in pods at the beginning of the rains, and thinned out subsequently, leaving a space of 18 to 20 feet each side. When the trees attain a girth of one

foot six inches after nine years, they should be carefully pollarded, taking care that the weak, wiry, and unhealthy shoots are removed first.* The stems should be cut off either with a sharp knife or axe leaving a space at the base to form forks to facilitate subsequent pollarding. When inoculating such trees care should be taken that they are not heavily inoculated (Fig. 7). If this simple precaution is not taken, the trees are likely to suffer from over drain and succumb to premature death. To fill up the gaps, it is necessary that a nursery should be established; if not, seedlings from congested areas may be utilized for filling in the gaps. It has been found that, trees planted twenty-two feet apart each way, there would be 114 trees per acre. A single tree could be expected to produce a seer at the lowest computation, the total produce would be 2½ maunds per year which at the reasonable rate of Rs. 25 per maund would bring in an annual income of Rs. 62-8-0. Deducting from this the cost of supervision and labour, there would be left a margin of Rs. 20 per acre provided the brood-lac used for inoculation has not to be bought. It is advisable to divide the estate into three blocks or coupes so as to give rest to the trees in each block by a well regulated system of crop rotation. This will invigorate the trees and prolong their life. Prior to the utilization of this tree for the propagation of the lac insect, its flowers yielded a fast to light dye, but with the introduction of aniline colours it has gone out of use. Its flowers were also used in indigenous medicine for liver complaints. Fomenting the liver with a decoction of flowers is said to yield some relief to the sufferer. The *dhak* gum has recently been used† in settling indigo. Mr. W. A. Davis, late Indigo Research Chemist to the Government of India, said :—

"From a number of trials made at different factories last season it appears clear that the use of *dhak* gum has no appreciable effect in lowering the quality of the indigo obtained, whilst in most cases it greatly increases the produce—in several instances by three to six seers of indigo per 100 maunds of plant."

The tree grows well in the loamy soils of North Bihar. Trees planted at Pusa in 1907 attained a bottom girth of 4 feet 8 inches to 5 feet 10 inches after sixteen years' growth (Fig. 6). Such trees, if properly pollarded, rested and inoculated, may be expected to yield from ten seers to half a maund per year. It is vigorous in growth and is not subject to the attacks of serious insect or fungal pests. Occasionally *Lithocolletis virgulata*, Meyr., and *Liocrobyla paraschista*, Meyr., are found

* Troup, R. S. Experiments in the pollarding of *Buttea frondosa* for lac cultivation. *Indian Forester*, Vol. XLV, No. 5, May 1919, pp. 223-233.

† Davis, W. A. The use of *Dhak* gum—its effect on yield and quality. *Indigo Publication* No. 3. *Agri Res. Inst. Pusa*, 1918.

FIG. 7. Ber *kusmi* lac on *palas*—Prominent growth of female tests on the leaf stalk Pusa. (Original.)

on the leaves making unsightly blotches, whilst *Eucosma conciliata*, Meyr., bores into the flowers. In the Central Provinces the bark of the roots of trees is used instead of rope for thatching purposes. In the United Provinces charcoal from prunings, etc., is ground fine and turned into small round flat cakes for the *hookah*.

The lac obtained from this tree is rich in colouring matter, and for this reason is commercially known as *rangeen*, meaning "full of colour." After washing, the resin that is obtained is inferior only to *kusum* lac in quality.

Kusum. The *kusum* tree, though not very common all over the lac-producing tracts, grows well in clayey soils by the sides of *nallahs* and rivers in the interior of forests, especially in the Singbhum Division in Bihar and Orissa and in the Chattisgarh Division of the Central Provinces. The tree grows gregariously in small groups mostly in the bends of *nallahs* or mountain streams where the soil is enriched with the washings from hill slopes. The *Kols* eat the fruit and extract an oil from the seeds which is used for burning purposes. The wood is strong and durable and is greatly used for harrows and oil-mills. The tree is very slow in growth and is generally raised from seed. From seed which should be collected from healthy trees in the year previous to that in which it is due to be sown, as freshly collected seeds, when sown, do not germinate well. It takes from sixteen to eighteen years for a tree to grow to a sufficient girth before it is able to withstand the inoculation with lac insects (Plate IV). It does not pollard well and it is for this reason that crops cannot be obtained annually from the tree. When once coppiced, it cannot be inoculated until a lapse of two or three years. But this disadvantage is more than counter-balanced by the heaviness and superior quality of the lac produced every second or third year. *Kusum* lac always sells at Rs. 5 to Rs. 10 more than either the *palas* or the *ber* stick-lac. It is generally utilized for the manufacture of Standard I shellac which is fine pale orange in colour. A special brand of tongue-lac was exhibited in the last Allahabad Exhibition during 1910-11 and it was the pride of the exhibitors and the wonder of the visitors. It was made from crystalline outgrowths one generally finds on the tests of females when they are fully developed and the larvæ therefrom are about to emerge. In the Dhamtari Range of the Raipur Division *kusum* brood-lac was put on *palas* trees and the resulting crop was fairly good (Fig. 5). A large number of trees in the same Division are being utilized now for lac cultivation, and these in course of time are expected to yield sufficient brood-lac for distribution. The trees, if found growing in groups, should be thinned out so as to enable fresh air and sunshine to enter the rows. The produce of lac from crowded

A. A *kusum* tree with lac on it.

B. A portion of a *kusum* branch showing growth of lac on it.

PLATE IV.

and ill-pollarded trees has been found to be less than those situated in the open with plenty of light and air to circulate between the rows. There are plenty of tracts of virgin forests in the South-Eastern parts of the Raipur Division, and it is expected that with the opening of the Raipur-Vizianagram Railway, full use will be made of this tract in utilizing it for lac production.

Pipal. The *pipal* tree grows all over India, but it is only in Assam that species of it are grown in numbers on the boundaries of fields, as well as the outskirts of villages. Lac, that grows of itself on these trees, is collected in parts of Bihar and Orissa, the United Provinces and Central India and the produce is sold to the local bangle makers. The quality of lac produced on *pipal* is much inferior to that produced in *palas* or *ber*, and as such fetches less price than either of these two. It is transparent pale yellow with a thin shiny texture fit to be turned into inferior grades of shellac only or being used to adulterate better qualities of lac. The tree does not coppice well, and it is for this reason that crops can only be obtained on it either biennially or triennially. It is only in Assam, on account of favourable climatic conditions and soil moisture, that trees in numbers could be raised by inarching and when of sufficient growth utilized for lac production. In other provinces, it is only by a well-thought out system of road arboriculture that the produce could be appreciably increased within the course of a decade or two. *Pipal* brood-lac should, as far as possible, be put on *pipal* trees.

Babul. It is in Sind only that lac on *babul* grows to any appreciable extent. It is found in the Jherruck forest and the banks of the Jamrao and the Nera canals. The tree grows luxuriantly on both sides of the canals and their distributaries, but no systematic cultivation is done. The blocks are leased out to contractors who try to collect as much lac as they could manage to collect. At a time when better prices rule in the Karachi market, attempts are made to collect as much as could be done within the term of the lease, without leaving any brood-lac on the trees. But when the prices fall, collections are either given up or partially made and the result is that the large sized, as well as young saplings, suffer from over-infestation and succumb to a premature death. This is a common sight to see along the railway line from Mirpur Khas to Digri. The trees look sickly from a distance, and from what I have been able to determine from personal examination of a number of trees, the conviction deepened into me that the main cause of the low vitality of the trees was their heavy infestation. Had this been regulated, regular crops would have been obtained without serious detriment to the trees. There are two main crops, *Chait* (May-June) and *Kati* (November). The collection is mostly done by Kachhis in

Hyderabad, Metari and Shikarpur. The major portion of the collections is sent to Karachi, but a fair portion goes to Mirzapur. Attempts made to grow lac in Bihar from brood-lac brought from Sind were not successful. In Sind the trees are leased in May-June and the contractors collect the crop in November and December every year.

Arhar or tur. Lac on *arhar*, known as *minimah* in the Garo and the Khasi Hills, is only grown in Assam. There is no other place in India where I have seen lac growing on *arhar* (*Cajanus indicus*). The reason is that it is only the climatic and soil conditions of Assam that are favourable to the growth and maintenance of the tree on the ground for more than one season. In other parts of the country the plant is annual and does not remain on the ground for more than ten months. In Assam, it is mostly sown in the Garo Hills in the beginning of the rains along with paddy or on the embankments of sugarcane fields. After harvesting paddy the plant is allowed to remain in the fields and is generally inoculated with lac a year and a half or two years after sowing. If the lac is put on early, the plant suffers and dies early. Each plant has been known to produce from four chittacks (8 oz.) to one seer (2 lb.) of stick-lac which is rich in colouring matter and does not bleach well. It is for this reason that *arhar* lac from Assam fetches less than either *kusum* or *palas* stick-lac. It is mostly used for adulterating other qualities of lac. At Palasbari in the Kamrup District, I saw the plants growing on sugarcane fields being tied together with twine or plantain bast to make a live fence to prevent the jackals from entering the fields and damaging the canes. The plants were about two years old and were from 3 to 4 inches in girth at the base of the stem. The lac encrustation on these was fairly healthy and good. The inoculated bushes looked white from a distance. If well cared for, the plants could remain on the ground for three or four years. They should be occasionally hoed round to conserve moisture and maintain soil aëration. They should also be carefully pruned to prevent flowering and thus to maintain vitality of the plant for a longer period. *Odontotermes* sp. sometimes damage the brushes to a great extent in the Kamrup District.

Attempts have been made to grow lac on *arhar* or *tur* (*Cajanus indicus*) in the Plains of India, but they have not hitherto been attended with success. Trials were made at Pusa by sowing a special variety of *tur* and inoculating the plants with *ber* (*Zizyphus jujuba*) brood-lac. The growth was poor and the cultivation was not financially a success. From what I have seen of the experiments conducted at other places, they have one and all met with the same fate. When *kusum* brood-lac is put on *arhar* plants six to seven months old, the establishment of

larvæ, as well as, the subsequent development of female resinous tests are very satisfactory on individual plants, but the crop as a whole has not been found a financial success anywhere. In recent experiments it was evident that when *kusum* brood-lac was put on *arhar* plants, the incidence of attack by *Eublemma amabilis* was considerably less than when the same brood-lac was put on *ber* plants in the neighbouring areas. Recently experiments have been started at Bangalore with *Shorea talura* brood-lac and it is to be seen how far the attempts are successful.

Other trees on which lac is found. Besides these, much lac is grown on *Zizyphus xylopyra* (vernacular) Hindi (*Ghoont Ber*) in Damoh and Saugor Districts in the Central Provinces, as well as in the States of Panna, Chhatarpur and Maihar in Central India. Specimens of lac are also found on the following:—

Litchi (*Nephelium litchi*),
Mango (*Mangifera indica*),
Custard apple (*Anona squamosa*),
Bullock's heart (*Anona reticulata*),
Asoka (*Polyalthia longifolia*),
Anjir (*Ficus carica*),
Montana bipinnatifida,
Prantij roxburghii,
Albizzia lebbek,
Hemelia patens,
Roses (Fig. 8),
Pomegranate.
Pithecolobium sp. (Fig. 9)
Dalbergia latifolia, (Fig. 11)
Acacia farnesiana,
Acacia catechu,
Pongamia glabra,
Ixora parviflora,
Leea crispa,
Flemingia congesta,
Acacia canescens,
Albizzia stipulata,
Zizyphus rugosa,
Cinchona calizaya, (*Fig. 10*)
Santalum album,
Loranthus sp.
Butea superba.

The quantity collected from the above is very small and therefore these trees have not hitherto been used for the cultivation of lac on a commercial scale.

Lac in the provinces.

Assam. The districts where lac in quantity is grown or cultivated are :—Sibsagar, Nowgong, Cachar, Kamrup, Garo and Khasi Hills, North Cachar Hills, Sylhet, Darrang, Lakhimpur and the Native State of Manipur. The chief *hats* are Palasbari, Chhayagaon and Boku. The main host plants of the lac insect are *Cajanus indicus*, *Grewia*, *Kydia* and *Ficus* spp.

FIG. 8. Lac on rose stem. (Original).

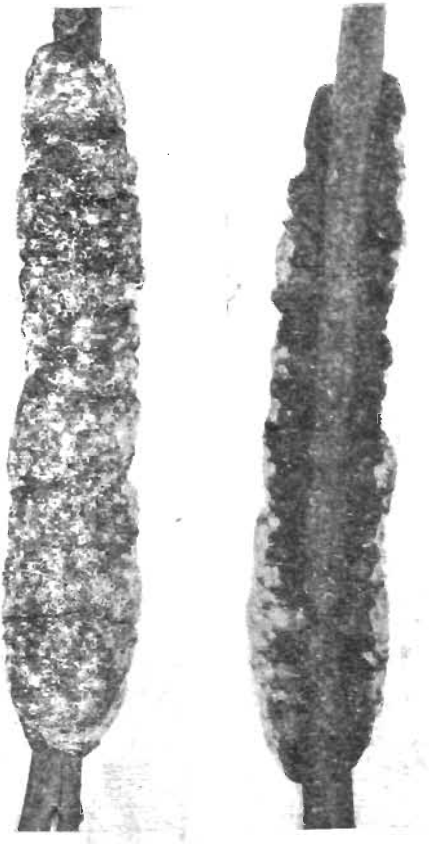


Fig. 9. Lac on *Pithecolobium* sp., Arambolly, Travancore. (Original)

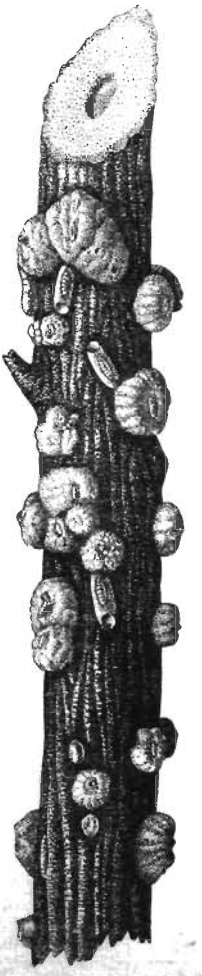


FIG. 10. Lac on *Cinchona calisaya*, Darjeeling, Bengal. (Original.)

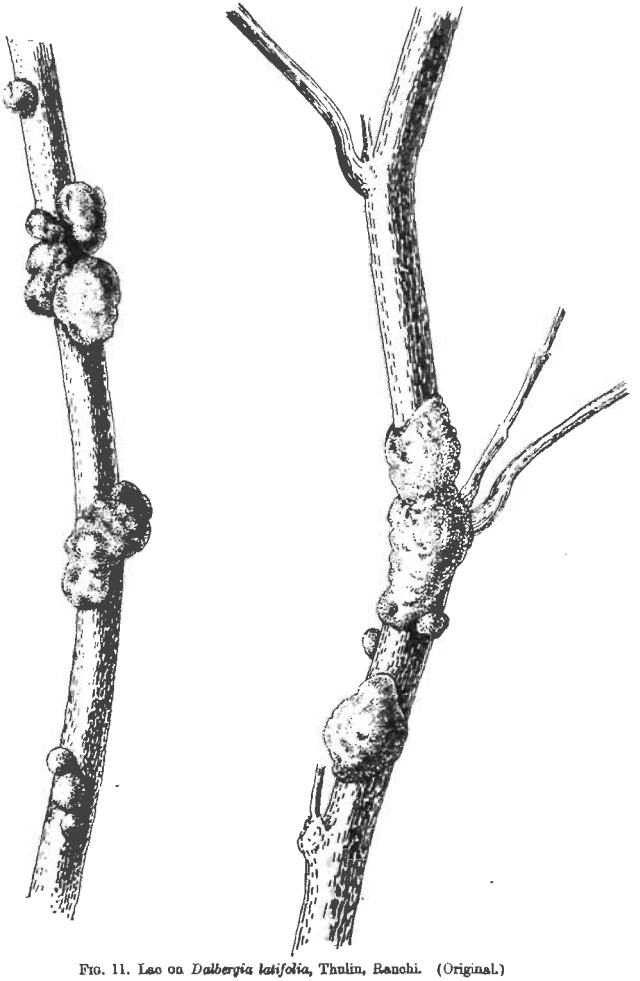


FIG. 11. Lac on *Dalbergia latifolia*, Thulin, Ranchi. (Original.)

Bihar and Orissa. The Province of Bihar and Orissa, together with the Central Provinces, forms a compact block which may be said to be the lac-growing tract of India. The quantity of lac produced in this tract represents the major portion of the total produce of the country. Not only is the largest quantity produced in this tract, the quality too is much superior to that produced in other parts of the country. The tract is rich in lac-producing trees, but awaits development. The *kusum*—the tree *par excellence* for the production of lac—grows luxuriantly and is found in large numbers in the area. There are extensive tracts of land full of *palas* and *ber* and the inhabitants of the tract are conversant with the details of lac cultivation. If the industry is organized on a co-operative basis, there are great possibilities of considerably increasing the outturn, thereby not only keeping out the wacker lac—a synthetic product—but increasing the output and thereby stabilising the prices of crude material from which shellac is manufactured. There are a number of lac-*hats* (markets) where quantities varying from 3,000 to 60,000 *maunds* could be obtained easily. (Map of India showing lac-*hats* and shellac factories). The most important markets within the Province are Balrampur, Chatra, Imamganj, Garhwa, Jhalda, Daltonganj, Pakur and Chaibassa. There are shellac factories at Imamganj, Pakur, Thulin, Jhalda, Purulia, Balrampur, Ranchi, Chaibassa and Chakradharpur. The majority of the shellac finds its way to Calcutta, from which port it is shipped to the United States of America and other Continental ports. The *ber* grows well in the Kolhan, and the *Kol* knows fully the economic importance of the *ber* tree, as it is rare to see a Kol village without a number of *ber* trees in it. If facilities are afforded for the supply of good, healthy brood-lac at proper term and at reasonal rates, there is every possibility of a considerable increase of stick-lac from this tract.

The Central Provinces. The districts where quantities of lac are collected are :—Raipur, Bilaspur, Saugor, Mandla, Bhandara, Hoshangabad, Bankheri, Damoh, Narsingpur, Jabalpur, Balaghat, Seoni, Chanda and Betul. The main food plants are *Zizyphus jujuba, Z. xylopyra, Butea frondosa, Schleichera trijuga* and *Acacia catechu*. The south-eastern part of the province contains a large number of *S. trijuga* trees which produce the finest lac from which pale-pellow or orange shellac is manufactured. The province as a whole could supply from 54 to 60 million lb. of stick-lac if properly worked. Nearly the whole of the produce was sent to Mirzapur, but now a great portion finds its way to Calcutta and other places in Chhota Nagpur. Besides these, there are considerable areas in Berar where lac is locally cultivated and collected, especially the Nandurbar forests, and as this area abuts

on the Hyderabad State, where active steps are now being taken to start lac cultivation, there is every possibility of this area becoming an important lac-growing centre in course of time. The south-eastern portion of the province is rich in *kusum* trees, and with the opening of the Raipur-Vizianagram Railway this tract will become an important lac producing area.

The United Provinces. The cultivation and collection of lac in these provinces are not so extensive as in the provinces noted above. Lac is, however, locally collected in the Garhwal Forests, Saharanpur (a part only), Kheri, Pilibhit, Kumaon, Gonda, Bundelkhand, Bahraich, Siwalik range, Rae Bareli and Partabgarh. The host plants are *Butea frondosa*, *Ficus* spp. and *Zizyphus xylopyra*. Besides these, there are small collections which are utilized locally for the manufacture of toys and bangles. The climatic conditions are in some localities a bar to the further extension of the cultivation, but on the other hand there are places which are quite suitable for cultivation provided good and cheap brood-lac is at hand to be put on the *palas* trees which abound in the plains districts. Mirzapur is an important centre of lac cultivation and manufacture and for nearly a century it was the only centre of shellac manufacture in Northern India. Even now, in almost all the factories in Calcutta, Ranchi, Purulia and other shellac-manufacturing places, the expert labour is wholly drawn from Mirzapur. These people move in families to remote places to earn their livelihood as shellac manufacturers and some of them are so clever that they cannot be displaced easily by local men without jeopardizing the interests of the manufacturer. The hilly, as well as the submontane tracts, as well as those adjoining the Vindhya mountains should suit for the propagation of the lac insect, but actual experiments have to be made to prove this.

The Punjab. As in the United Provinces, there are large tracts wherein regular cultivation and collection are practised. There are local collections in Gujrat, Ambala, Jalundhar, Hoshiarpur, Gurdaspur and the Kapurthala State. In Hoshiarpur especially in the Una tehsil it is said, three to four thousand maunds are collected locally and the produce finds its way to the shellac factories at Amritsar. Lac is found growing spontaneously on *Ficus* spp., *Butea*, *Acacia* and *Zizyphus*. On the whole the collections are not very large, but in some tracts the host plants are present in numbers and only experiments can show whether these could be used for the propagation of the lac insect, so as to yield some income.

Kashmir. Small quantities of lac are collected on *khair* (*Acacia catechu*) in the Billawar forests and attempts are now being made by the

State Forest Department to extend the cultivation in the areas where the insect flourishes on the *ber* and the *khair*.

Bengal. Lac to some extent is grown and collected in the districts of Birbhum, Murshidabad, Malda, Bankura, Midnapur and Rangpur. The host plants are *Butea*, *Zizyphus* and *Schleichera*. There are considerable areas in Birbhum, Midnapur and Bankura Districts which could be utilized for lac cultivation as these abound with *Butea frondosa* plants. In the Murshidabad District, *Z. jujuba* plants are grown on field embankments and are annually inoculated with lac which the cultivators purchase in the local *hats*. The system of cultivation is quite unique and I have not seen anything like this attempted in other parts of India. The plants are pollarded very carefully and inoculated with lac when they have got a number of long, succulent stems. The plants appear very trim, bushy and luxuriant in growth with a good number of healthy stems. The produce from the trees is either reserved for seed or scraped and sold locally. The little extra income that the cultivator gets is used to pay the rents, leaving the produce of the fields for the use of his family. A cultivator having 10 to 20 trees pollards 10 trees during December when they are dormant and utilizes the brood-lac from the other trees for inoculating them in June and selling the surplus as brood-lac in the local *hat*. In this way, he seldom gets seed from outside and is able to utilize the *Zizyphus* trees fully for the production of lac. When the market rates for stick-lac are high, the cultivator is able to pay off the rents from the sale proceeds of his trees, without having the necessity of obtaining money on loan. In pruning, inoculating, cutting and scraping lac from trees on his field-embankments, the cultivator is assisted by the members of his family and has not to pay for extra labour. This leaves him an ample margin wherewith to continue the cultivation from year to year. An extension of this system widely throughout the districts and the adjoining places is bound to improve the material condition of the cultivators, as with the sale proceeds of the subsidiary produce they will be able to pay off the rent, thereby retaining the produce of the fields entirely to themselves. In doing this not much time or labour is required and the whole work is managed easily by a cultivator assisted by members of his family. To get an idea of the effect of growing lac as a subsidiary industry in rice-growing tracts, one has to see the tract of land extending on the south of the Ganges from Jangipur to Farakka in the Berhampur district, Bengal. The area covers approximately sixty square miles and is thickly studded with large-sized *ber* trees, carefully pollarded and yearly utilized for the propagation of lac. The material condition of the inhabitants of the tract is much better than where paddy only is the principal crop. In this

tract two shellac factories have been established to utilize the local produce and more are contemplated to be established soon. At least one will be much struck with the way the work is carried on in this tract and I wish this system could be adopted in other similar tracts where rice is the principal crop.

Bombay. In this presidency not much lac is either grown or collected, but whatever little is obtained it is collected in Kolaba, Surat-North Thana, Central Thana, South Thana, Panch Mahals, North Khandesh, West Khandesh, East Khandesh, Nasik, Satara, Ali Rajpur, Udaipur, Deogad, Baruja and Hyderabad in Sind. The principal food-plants are *Butea, Ficus* spp., *Schleichera, Zizyphus jujuba* and *Z. xylopyra, Albizzia lebbek, Acacia arabica, Acacia catechu, Xylia dolabriformis, Prosopis spicigera* and *Eugenia dalbergioides.*

In Sind lac grows on *Acacia arabica* in the Jerruk forests near Hyderabad as well as the banks of the Jamrao and the Nera canals. Besides this tract, I have not seen any other tract where lac is found growing by itself on the *Acacia* trees. The reason why the insect should not flourish on the same food-plants, say in the north of Sind, is not known. In the neighbourhood of Hyderabad in Sind the insect is said to flourish well on such trees only as are either low in vitality or are about to die. The reason why the insect shou'd show partiality for such trees remains to be investigated. I think in the first place it has to be ascertained whether such a statement is true. Anyhow, it remains to be tested by actual experiments whether the insect will propagate itself on seedlings raised from seed broadcasted in areas adjoining the present lac-producing areas and whether the brood-lac raised on these could be utilized for propagation in the northern parts of the province. In this connection it has also to be determined whether the influence of subsoil water has any effect on the growth of the lac insect on *Acacia* trees, and whether the alkalinity of the soil is in any way connected with the growth or deterioration of the lac insect or not.

Madras. Local collections only are made in Kanara and Mysore on *Shorea talura.* Some lac is also collected in Ganjam, Baripada, Trichinopoly, Kumbakonam, Banganpalli and Jeypur State.* There are also local collections in the Omarkote range within an area of 200 sq. miles. The majority of lac used in the Presidency is obtained from Burma and the silk-dyers prefer Burma lac which is richer in colouring matter than the Indian stuff. The lacquer workers at Channapatna utilize the lac

*The information regarding local collections has been obtained from the shellac manufacturers at Mirzapur and other shellac manufacturing centres, who have their own agents in such localities.

grown and collected locally. Some lac is also grown at Dasnapalli and Kalkarney near Bangalore on *Jalla* (*Shorea talura*) and at Tumkur. The presence of *Schleichera trijuga* in numbers has now been found at Shimoga and attempts are being made to utilize these trees for the production of lac with *kusum* brood-lac from the Central Provinces. It is also contemplated to utilize the large numbers of *Xylia* sp. trees which are present in the forests for the propagation of lac. Experimental propagation of lac on *Acacia farnesiana* with local brood-lac and *kusum* brood-lac on *Flemingia congesta* have given promising results. I think that *Leea crispa*, as an introduced lac host-plant, will not be proved suitable for lac cultivation. In Travancore, collections are made in one forest range only, the food-plants being *Odina wodier*, *Ficus religiosa*, *Careya arborea*, *Spatholobus roxburghi*. But with the organization of the Industries Department in the State, considerable attention is being paid now to the cultivation on scientific lines within the State, and it is expected that the suitable portions of the forest will be soon utilized for the production of lac in quantities to meet the local demands as well as those of the neighbouring Presidency.

Ceylon. The Ceylon Agricultural and Horticultural Society sent an Agricultural Inspector for training in lac at Pusa and on his return experimental cultivation was started on *Zizyphus jujuba* (Ceylonese—*masan*) and *Schleichera trijuga* (Ceylonese—*kon*) and it was reported that the lac insect had flourished well on the latter food-plant but later on *Eublemma* sp. did considerable injury to lac on trees.

Burma. Lac in considerable quantities used to be collected and exported in the form of stick-lac which contained more colouring matter than Indian lac. But now the exports have fallen off considerably, It is collected in Thayetmyo, Prome, Tharrawady, Henzada, Arakan, Upper Chindwin and Southern Shan States. In one year a set of villages in the Pakoku Chin Hills produced 100,000 lb. during a year. Large quantities are collected on the borders of the Shan States and brought into the country to be either exported along with Burma lac or turned into shellac. The produce of the tract bordering on Indo-China finds its way into the interior and is exported chiefly to India along with Burma lac. The country as a whole has great possibilities of development, and if properly worked, is likely to yield large quantities of stick lac which could be utilized for the manufacture of seed-lac or shellac. Next to Assam, the Central Provinces and Bihar and Orissa, Burma bulks large and is capable of producing half, if not more, of the normal requirements of the country. Lac from Burma is used largely in Madras for dyeing silk and to some extent wool. The food-plants of the lac insect are *Pithecolobium*, *Cassia*, *Zizyphus*, *Dipterocarpus*, *Shorea obtusa*,

Schleichera, *Albizzia*, *Tamarindus*, *Butea*, *Cæsalpinia*, *Dalbergia obata* and *Xylia*.

Central India. Lac in some quantity is also collected in the Native States of Rewah, Nagod, Maihar, Chhatarpur and Panna. Attempts are also being made at Rutlam, Gwalior and Jodhpur to grow lac, but how far the experiments have been successful is not known. Recently a small quantity of broodlac was found on a *ber* tree near Jodhpur. The texture and colour of the resinous tests was quite unlike those of *ber* lac found in Bengal and Chhota Nagpur plateau. At Jodhpur, *Ceroplastes* sp. was mistaken for the lac insects and attempts were actually made to propagate it. (Fig. 12). In Rewah considerable quantities are

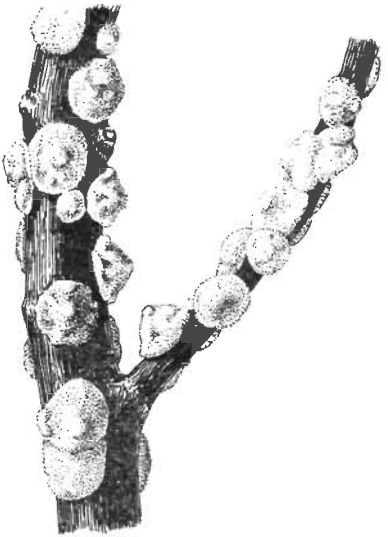


FIG. 12. *Ceroplastes* sp., Jodhpur, Central India. (Original.)

collected in the forests and worked into shellac in the factory at Umaria. But since last year the out-turn has fallen off considerably, due no doubt to the intensive system of collection practised in the previous years.

From the above it will be seen that lac is found in most of the provinces of India and that in the majority of cases no attempts are made to grow the insect on its food-plants. Whatever quantity is found to grow on the plants is collected and sold to the nearest dealer in stick-lac. In the majority of cases the collection is done by aboriginal tribes who inhabit the outskirts of forests. These people barter lac for salt, cloth or trinkets or such other small luxuries of life. The *bania* or the local dealer collects the local produce and sells it to another merchant who sends it either to Mirzapur or to Calcutta. The actual producer has no dealings with the manufacturer and the result is that the major portion of the profits is appropriated by the middleman. From the above it will also be seen that the greater portion of the lac brought for sale is collected as it is found growing on its food-plants and that no attempts have been made to cultivate the insect on scientific and business lines. If the lines of work laid down herein are followed, it will be found that localities where *palas* (*Butea frondosa*), *Schleichera trijuga* and *Zizyphus jujuba* plants abound, could be utilized for the production of lac. The result will be that plants which have ceased to be of any economic value now will yield fairly good returns on the amount invested in developing the cultivation. Besides this, there will be the advantage of improving the material condition of the people, especially the aborigines inhabiting the forests, and steadyiug the market. The present violent oscillations in the prices of the crude material would be avoided if not completely eliminated and the possibility of the introduction of synthetic or other cheap substitutes would be postponed indefinitely. Much could be done to extend the cultivation of lac by starting suitable nurseries for the distribution of healthy brood-lac at proper times and at cheap rates, so as to enable even the proprietor of a few trees only to inoculate his trees. At the present time it is practically impossible to obtain good healthy and cheap brood-lac for inoculation purposes. The prices charged are not only exorbitant but prohibitive as well. I know from past experience that, when stick-lac was quoted at Rs. 20 per maund in Calcutta, the prices charged for *kusum* brood-lac were ranging anywhere between Rs. 40 to 60 per maund, and as it is known that the greater portion of the stuff consists of wood and colouring matter, the actual price of resin obtained by scraping the brood-lac sticks works out to a prohibitive figure. This is mainly responsible for limited cultivation and subsequent production. I know for a fact that a large number of cultivators go long distances from their places in search of healthy brood-lac. They sometimes resort to hilly tracts where they think they willl be certain of obtaining healthy brood-lac at fair rates. In some places the lac cultivators having obtained abnormal prices for their

crude material have taken the trouble of exchanging their brood-lac with others living in hilly tracts or in localities where the brood-lac is considered to reproduce well. With so many obstructions and with an ever-changing market, it is no wonder that the cultivation should have remained in so precarious a condition as is the case at the present time. Thus it seems reasonable that in any scheme of future development of cultivation, the provision of nurseries in suitable localities should not be lost sight of. Besides this, facilities for the transport of brood-lac are so cumbrous and the freight charges so heavy that it is not only impossible but risky to import brood-lac from other localities. I have personally experienced the trouble of obtaining brood-lac from places other than Pusa. The lac cultivators are at first reluctant to undertake the work of packing and sending out parcels of brood-lac by rail. The question of despatch by post is prohibitive on account of the heavy postal charges. If, however, they are induced to undertake such work, the transport difficulties are so great that all the efforts end in failure. I have seen instances where crates containing brood-lac have been allowed to lie on railway station platforms in the sun for days together before they were despatched to their proper destinations and as everybody knows, if brood-lac is exposed to the sun for a number of hours, the resin melts, the holes of exit for the larvæ are closed and they are unable to emerge. Besides this, with heat fermentation sets in in the body contents of the females and the result is that the nymphs are stifled to death with heat and are unable to emerge. The railway authorities are perhaps unconscious of this fact, otherwise proper precautions would have been adopted by them to ensure safety of the brood-lac crates entrusted to them for transport. Because the question has an important bearing on the problem of future development of the lac industry, I have thought it proper to touch upon it here.

With the question of the establishment of nurseries, the task of establishing the species of the lac insect is of profound interest. A thorough study of the question in all its aspects is bound to yield data of considerable economic importance. With the fixation of species it would be possible to extend the cultivation of the particular species in well-defined areas and therefrom to extend the cultivation. This work was anticipated and collections were made from all parts of lac-producing areas in India with the collaboration of the forest officers. This collection is at Pusa and requires to be worked through. Specimens, both dry and wet, have been collected of cultivated as well as of wild lac and have been preserved. In this way a good collection has been got together and would soon be worked through. As is well known, with the fixation

of species found to occur within the important lac-producing tracts as well as elsewhere, the fixation or knowledge of the swarming of larvæ in both the seasons is very essential to the development of cultivation. With the fixation of species and the periods of swarming of larvæ in particular tracts, the work of expansion would be considerably facilitated and broadened. When this has been done it will be time to look after the details of cultivation. As is well known the introduction of lac into the market came after the price of cochineal—which was used for dyeing silk—had gone very high. It was then that the consumers' attention was drawn to the substitution of a cheaper stuff which would *partially, if not wholly, fulfil the requirements of the trade of the times*, and the lac-dye was found to meet the exigencies of the situation well. The dye was extracted and used for colouring purposes and the resin was *left unutilized*. Later on when the special properties of the resin came to be known, it was used along with the dye for various other purposes. From this time onward the exports of resin began to rise until to-day they reach the unprecedented total of £5,443,293. This represents the quantity exported from the port of Calcutta alone. If, however, such statistics were available for the other ports of Karachi, Bombay and Madras, along with the quantity consumed in the country, which is in no sense a negligible quantity, it will be found that the total annual *production of lac in India and Burma is well over 170-200 million lb.* This quantity is raised annually, when the insect has been subjected to ill and drastic treatments which, if not effectual for its total extinction, have lowered its vitality to such an extent that it may be said to be the progeny of degenerated parents which are not as yet free from the baneful effects of processes which are antiquated as well as effete. If one looks at the methods adopted for collecting the yearly produce, one is struck with the profound vitality displayed by the insect and I think it is its prolific fecundity which has saved it from total extinction. The cultivators now have recourse to measures of collection such as were adopted by their forefathers centuries ago. But the times have changed *considerably. What was once a paying item has ceased to be such.* What was once eagerly sought after is now discarded. The introduction of aniline colours has done much to bring about this change. But as the lac cultivator is illiterate, and lives in remote corners where ideas of modern developments do not reach him, he persists in adopting old and antiquated methods of collection. The lac-dye has ceased to be an article of commerce, and attempts are made to obtain resin which is as much free of the colouring matter as is possible to obtain. But the lac-cultivator, irrespective of these changes in the commercial world, still continues to collect lac before swarming has taken place, with the

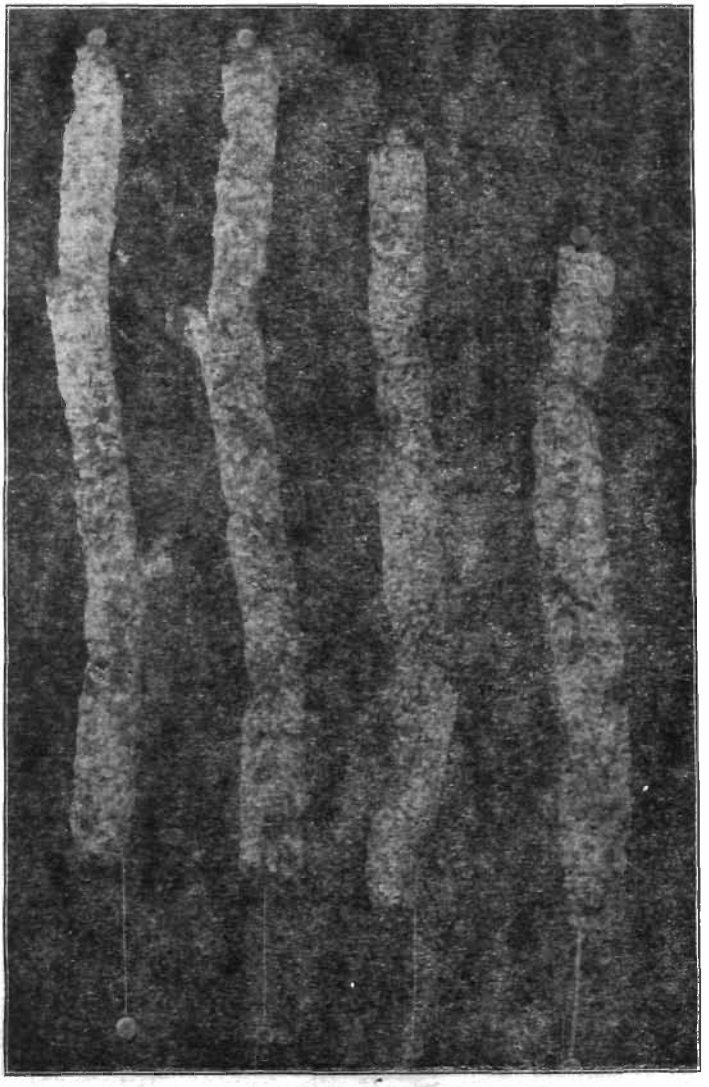


FIG. 13. *Ber* broodlac sticks showing effect of selection after 4 years. (Original.)

result that the larvæ are killed outright by exposure of the lac-bearing branches to the heat of the sun. The result is that the healthiest and most virile larvæ are killed off, leaving behind stragglers which are not so vigorous as they should be. In a count made at Pusa of larvæ of *Zizyphus jujuba* lac, it was found that 52 days after establishment, 25 to 30 per cent. of them had failed to establish themselves and to produce resin. From examinations made of the larvæ from establishment to maturity it was found that the mortality varied from 40 to 83 % (PlateV).

Ber broodlac on *ber*	58%
Kusum broodlac on *kusum*	40%
Kusum broodlac on *ber*	65%
Kusum broodlac on *khair*	63%
Palas broodlac on *ber*	83%

In this connection, some work has been done at Pusa regarding selection and hybridization. At the time of removal of the crop from the trees, only those branches were selected for seed which were uniformly covered with lac encrustation, had a thick coat of whitish floss on them and had fewer holes of exit of *Eublemma amabilis* on them (Fig. 14). In the fifth year, the results were very encouraging and the encrustation on the majority of trees was as seen in Fig. 13. If the material in various places is examined in this light, it will be found that in places even a larger percentage fails every year to establish and subsequently to reproduce itself. This is no doubt one of the causes of the short supplies so much complained of by the shellac-manufacturers from time to time. If, however, the lac cultivators are informed of the mischief they are doing unconsciously, I am sure they will improve their methods and will begin collecting the material after the larvæ have swarmed out. No doubt much could also be done by the manufacturers. If they will adopt the practice of paying the cultivators on the proportion of resin to lac-dye in a sample, the cultivator would soon modify his ways and would adapt himself to changed circumstances. The manufacturers should insist on purchasing stick-lac which contains a smaller proportion of lac-dye than one which has been collected before swarming has taken place and is consequently rich in colouring matter. This will effectively put an end to the unscientific method of gathering lac thereby consigning to death a huge number of larvæ which would otherwise have produced lac.

Larvæ on her branch showing difference between healthy (red) and unhealthy (reddish-black) larvæ, three weeks after establishment.—Pusa. (Original.)

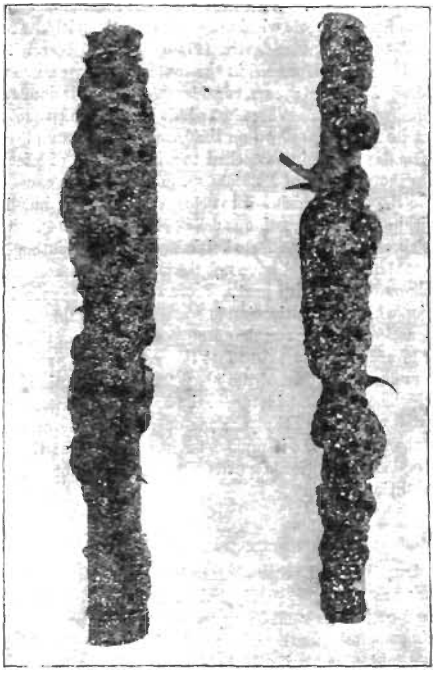


Fig. 14. Holes of exit of *Eublemma amabilis* in introduced lac at Banganapalle, South India, November 1914.

Localities suitable for lac cultivation.

Places which are neither very hot nor very cold and where the annual rainfall is about 30 inches are suitable for lac cultivation. Moisture is a great necessity for the successful development of the insect, but if it is in excess it affects the crop injuriously. Dry, arid places are to be avoided in starting the cultivation. Extremes of heat and cold retard

the growth of the insect. With heat the resin softens and affects prejudicially the female insects within the resinous cells with the result that they succumb to a premature death. (Plate VI. figs. 5, 6 and 7.) In such cases the cells become depressed in the centre dorsally and considerably shrunk laterally. In some years, considerable damage is done to the crop in the beginning of May. Where hot winds locally known as *Loo* prevail the resin melts and drops down on the leaves or the ground below, the bodies of females remaining attached to the branches of affected trees. In localities the presence of *Pythium* sp. in female tests causes a heavy mortality in the larvæ which fail to eclose satisfactorily, but lie dead in clusters within the female resinous cells (Plate VI, fig. 4). Such cells, as have not been adversely affected either with heat or pathogenic fungi remain normal in shape and have not the dorsal depression as is conspicuous in those affected with heat. From what I have seen in most of the localities where lac cultivation is successful the subterranean water level has a marked influence on the success or otherwise of the cultivation. Where the level falls below thirty feet the trees do not produce lac well. As a test for the suitability of the place for lac cultivation, only a few trees should be inoculated in the beginning, and if on these the lac flourishes well throughout the year the operations may be extended or otherwise abandoned ; for it must be remembered that the success or otherwise of lac cultivation depends very much, if not entirely, upon climatic conditions.

Instruments and other accessories required for the work.

The instruments and other accessories required to start and carry on the work are very few. Only knives as shown on Plate IV, some plantain bast or jute or sann-hemp fibre are all that are required. In the beginning a small quantity of brood-lac is also required to put on the trees. A straight-edged knife (Plate VII, fig. 1) is required to prune and cut the lac-bearing branches which are away from the stem or the main branches. A curved or double-edged knife (Plate VII, fig. 3) is required to dress the trees and to cut the lac-bearing branches into lengths varying from 9 inches to 11 inches. The other knife (Plate VII, fig. 2) is required to trim the lac-bearing branches before cutting them into pieces, and to scrape *ber* lac. The knives should, if possible, be of steel to withstand rough handling and must have a sharp edge. Their outer edge should, if possible, be thick to impart force and to make clean cuts. A lighter knife is apt to slip off while pruning tough branches and to produce jagged ends, which would have to be dressed to prevent water lodging and setting up decomposition. Knives of the pattern

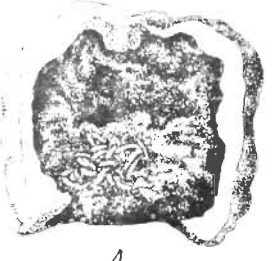
the growth of the insect. With heat the resin softens and affects prejudicially the female insects within the resinous cells with the result that they succumb to a premature death. (Plate VI. figs. 5, 6 and 7.) In such cases the cells become depressed in the centre dorsally and considerably shrunk laterally. In some years, considerable damage is done to the crop in the beginning of May. Where hot winds locally known as *Loo* prevail the resin melts and drops down on the leaves or the ground below, the bodies of females remaining attached to the branches of affected trees. In localities the presence of *Pythium* sp. in female tests causes a heavy mortality in the larvæ which fail to eclose satisfactorily, but lie dead in clusters within the female resinous cells (Plate VI, fig. 4). Such cells, as have not been adversely affected either with heat or pathogenic fungi remain normal in shape and have not the dorsal depression as is conspicuous in those affected with heat. From what I have seen in most of the localities where lac cultivation is successful the subterranean water level has a marked influence on the success or otherwise of the cultivation. Where the level falls below thirty feet the trees do not produce lac well. As a test for the suitability of the place for lac cultivation, only a few trees should be inoculated in the beginning, and if on these the lac flourishes well throughout the year the operations may be extended or otherwise abandoned : for it must be remembered that the success or otherwise of lac cultivation depends very much, if not entirely, upon climatic conditions.

Instruments and other accessories required for the work.

The instruments and other accessories required to start and carry on the work are very few. Only knives as shown on Plate IV, some plantain bast or jute or sann-hemp fibre are all that are required. In the beginning a small quantity of brood-lac is also required to put on the trees. A straight-edged knife (Plate VII, fig. 1) is required to prune and cut the lac-bearing branches which are away from the stem or the main branches. A curved or double-edged knife (Plate VII, fig. 3) is required to dress the trees and to cut the lac-bearing branches into lengths varying from 9 inches to 11 inches. The other knife (Plate VII, fig. 2) is required to trim the lac-bearing branches before cutting them into pieces, and to scrape *ber* lac. The knives should, if possible, be of steel to withstand rough handling and must have a sharp edge. Their outer edge should, if possible, be thick to impart force and to make clean cuts. A lighter knife is apt to slip off while pruning tough branches and to produce jagged ends, which would have to be dressed to prevent water lodging and setting up decomposition. Knives of the pattern

1

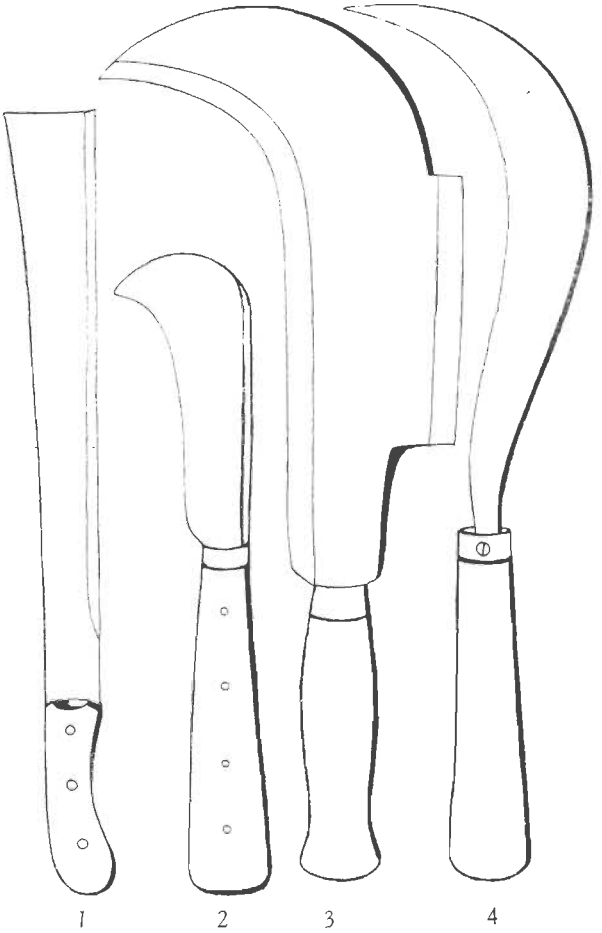
3



4

EXPLANATION OF PLATE VI.

1. Lac on *Ghaut* (*Zizyphus xylopyra*) Damoh, C. P. Female tests from which larvæ have emerged X4
2. Lac on *Ghaut* (*Zizyphus xylopyra*) Damoh, C. P. Female tests affected with heat X4
3. *Longitudinal section of a female test showing exuviæ of larvæ remaining* within the test X12
4. Longitudinal section of a female test showing dead larvæ within it . . . X15
5. A female resinous test affected with heat showing depression dorsally between the anal tubercle and the anterior spiracles X9
6. A female resinous test severely affected with heat showing a deep depression in the centre dorsally X15
7. Longitudinal section of a female test showing effect of severe heat on the female within the test X15



VARIOUS FORMS OF PRUNING KNIVES.

1. A good pattern, a heavy straight blade for pruning.
2. A tea-pruning knife for trimming cut-ends.
3. A bill-hook for very heavy work on big trees.
4. The ordinary Indian pattern made in the bazars at a cost of eight annas.

given on Plate VII could be easily made locally or procured from any hardware merchant in Calcutta or Bombay at one rupee each.

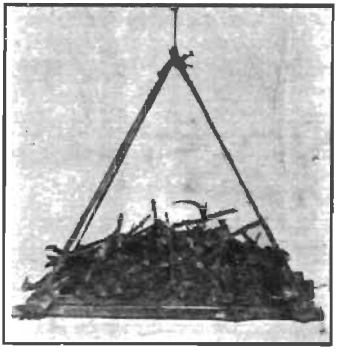


Fig. 15. *Shikia* for taking brood-lac up the trees.

Besides these, a few bamboos are also required on which to aërate the brood-lac sticks prior to their being put on the trees. If, however, large *ber* trees are to be inoculated, *shikias* (Fig. 15) will be found very convenient for hauling quantities of brood-lac sticks up the trees at the time of inoculating them. In the case of *palas* if a large number of trees are to be inoculated, bamboo receptacles (Fig. 16) will be found very convenient for putting on the brood-lac expeditiously. In the Central Provinces bamboo-mats are also used for inoculating *ber* and *palas* trees in large numbers (Fig. 17).

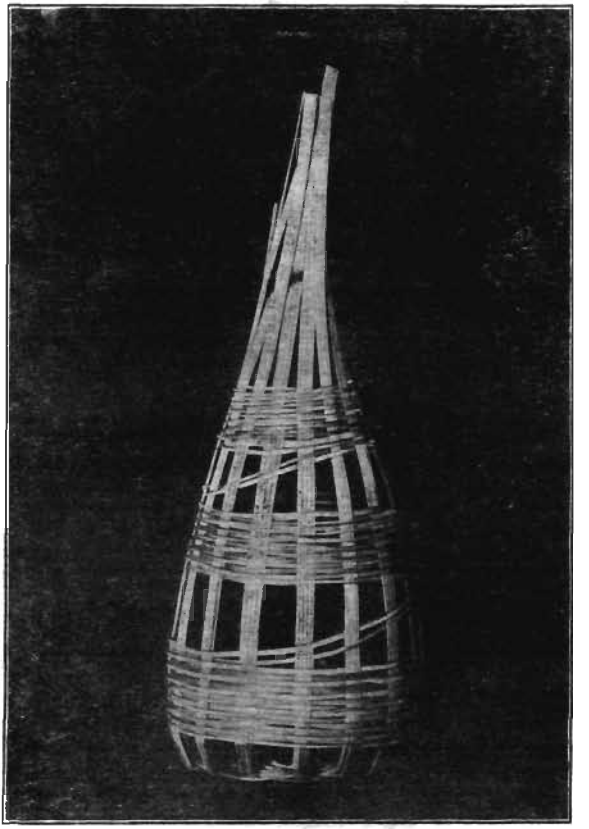


FIG. 16. Bamboo receptacle for inoculating *ber* and *palas* trees.

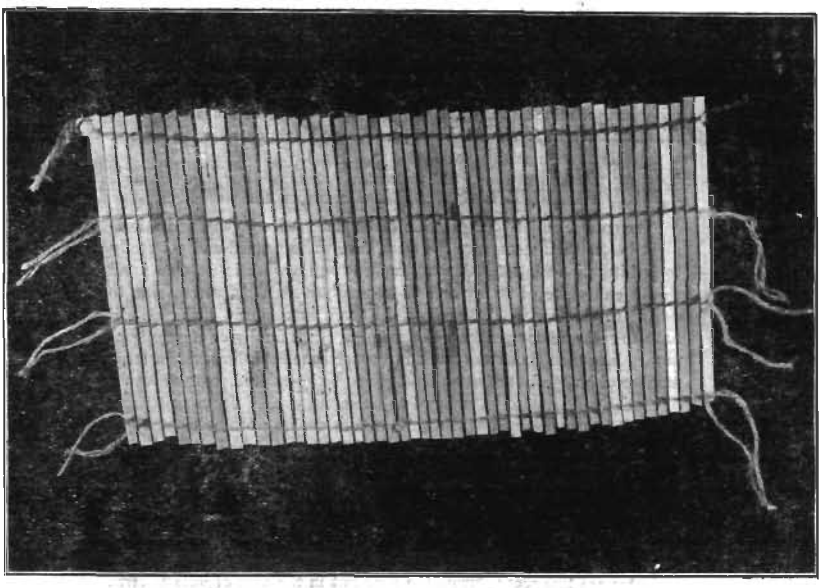


FIG. 17. Receptacle made of split bamboo for inoculating *ber* and *palas* trees. (Original.)

Experiments were made at Ranipur, Saharanpur District, United Provinces, on the best method of inoculating *palas* trees and Mr. R. S. Troup found these bamboo-receptacles much adapted to the purpose for which they were recommended.* The advantage in these receptacles is that they can be made easily locally and stocked to be re-used the following years. Such receptacles could either be made of split bamboo pieces, as shown in Text-fig. 16, or from dry *arhar* stalks of which fruit baskets are generally made in Northern India. Another advantage in the use of these receptacles is that brood-lac from one coupe may be completely removed and utilized for inoculating pollarded trees in the other coupe. Such sticks as show a large number of holes of exit of *Eublemma amabilis* should be discarded and fumigated with carbon bisulphide as soon as the inoculation is finished.

Time and labour required to carry on the work.

The emergence of young insects takes place twice a year, and a fortnight before each emergence the trees have to be pruned and got ready to facilitate inoculation. A week in June and a week in October is all that a cultivator of 20 *ber* and 60-80 medium-sized *palas* trees has to devote to the work. To carry on the work successfully either he will have to seek the co-operation of a member of his family or engage temporary labour to finish the work in proper time. If, however, a large number of *ber*, *palas* or *kusum* trees are to be inoculated, regular gangs of coolies will have to be engaged to finish the work. From past experience it has been found that a gang of four coolies working eight hours per day is capable of inoculating 70 to 100 *palas* trees of medium size. In this work, it must be borne in mind, it is essential that the work of cutting, removing and putting on the brood-lac must be done in proper time. A week's delay produces unsatisfactory results.

Crops during the year.

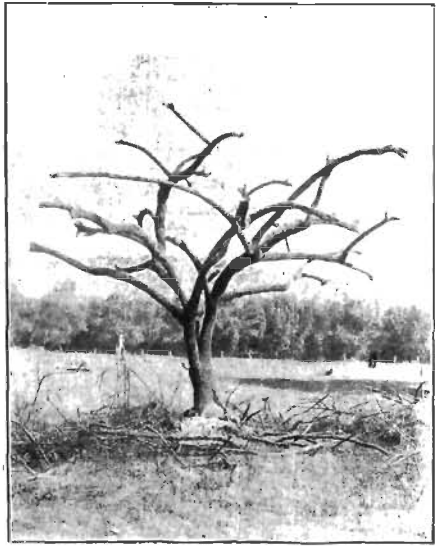
There are two crops during the year but in the case of *jalla* (*Shorea talura*) in Mysore there are three crops within thirteen months. The

* Troup, R. S., Experiments in the pollarding of *Butea frondosa* for lac cultivation *Indian Forester*, Vol. XLV, No. 3, May 1919, p. 231. "Different methods of tying up the lac were tried, but the most successful was that advocated by Mr. Misra, namely, to place sticks of brood-lac in loosely constructed baskets and tie the baskets up in the branches. In the present experiments about 40 to 50 sticks of lac were placed in each basket, and varying numbers of baskets up to 14 were hung in each tree. Generally speaking, it was found advisable to fix up one basket at the base of each small clump of pollard shoots, either by pushing the basket into the clump or by hanging it up by means of a wire hook. The basket should, as already pointed out, be removed as soon as swarming is over, and for this purpose a few marked shoots, low down on a tree, should be impregnated and watched from day to day during the time of swarming in order to ascertain when swarming is at an end."

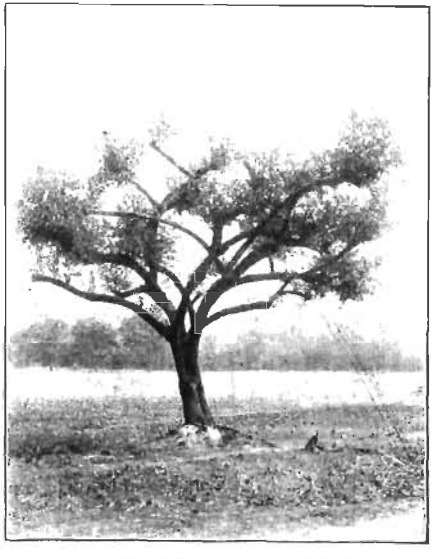
A. A badly pruned *ber* tree.

B. A young *ber* tree headed back

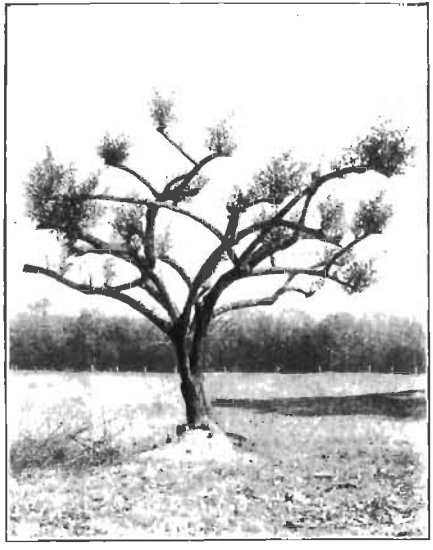
PLATE VIII.



A. An old *ber* tree severely pruned.



B. The same tree showing growth of shoots.



A. The same tree showing growth of healthy shoots at ends of branches.

B. The same tree ready for inoculation

PLATE X.

first inoculation is done in February and the crop is ready in the following May-June. From inoculations made in May-June, a second crop is obtained in September and from inoculations made in September the third crop is obtained in December-January. Of the three crops May-June crop is the best. In the case of *babul* (*Acacia arabica*) lac tract in Sind and *arhar* or *mirinah* (a variety of *Cajanus indicus*) lac tract in Assam, so far as it has been possible to determine, there are only two emergences during the year. That which is gathered during June-July is called the *Baisakhi* crop from the name of the month Baisakh, in which the crop is generally collected, and the other the *Kartiki*—from Kartik, the month in which the crop is gathered. The former is in some localities also called the "*rangeen*" on account of the sticklac—especially *palas*—containing a large amount of colouring matter. Of the two, the *Baisakhi* crop is the larger and better but in some places the *Kartiki* crop is considered to be the principal crop of the year. It takes nearly eight months and a half to mature and in consequence the proportion of resin to lac-dye is greater than in the following *Kartiki* crop. Besides, it is partly immune from the attacks of predators and parasites as it passes through winter during which time most of the injurious insects remain dormant in one stage or the other. The *Kartiki* crop takes only three months and a half to mature, and in consequence the proportion of resin to lac-dye is much less than in the previous *Baisakhi* crop. In some years the crop is so much attacked by predators and parasites that it is a partial failure. For these reasons the growers in Bengal and the Central Provinces—who produce the largest and best kind of lac—reserve most of their *Kartiki* (winter) crop for seed and do not sell it.

From a tree only one crop is obtained yearly. In the beginning the trees require to be pruned, but later on the removal of the lac-bearing branches is a pruning to the trees. If, however, it is desired to obtain two crops during the year, the trees to be inoculated should be divided into three groups. The trees in the first group are to be pruned in February and inoculated in the following June, whilst the trees in the second group or block are to be pruned for the following October inoculation. In October the crop from the first group is gathered and put on to trees in the second group which have already been pruned for the purpose. From past experience it has been found that it pays in the long run to give rest to the trees. If these are continuously utilized for lac production, their vitality is lowered and in subsequent years the crop is not so good as before. In some cases the tree sends forth corky shoots and these become unfit for inoculation. Rest to the trees is essential if they are to be exploited to the full for lac production. It is, therefore, advisable to divide the area or the trees into three coupes or blocks

and to arrange the rotation of inoculation in such a way that one block would get rest for one season at least. In cases of soil exhaustion or over-inoculation trees die prematurely. To replace them with healthy trees, a nursery should, if possible, be maintained somewhere near the plantation.

Pruning trees.

Before starting cultivation, care should be taken that the trees on which lac is intended to be grown have sufficient tender branches to enable the lac insect to establish itself. If this is not so, the trees should be pruned carefully. This is especially necessary in the case of the *ber* tree which responds to careful pruning by sending forth a large number of vigorous and succulent shoots. The *palas* does not ordinarily require pruning, and the same is the case with the *kusum*. For pruning *ber* trees two kinds of knives are required (Plate VII, figs. 1 and 2), and these must be very sharp and thick at the outer edge to impart force to the cuts. If one is starting cultivation on *ber* trees for the first time the trees should be pruned when they are dormant and the sap is not flowing upwards. In Northern India this is preferably done in the beginning of February for the June inoculation and in the beginning of June for the following October inoculation. At the time of pruning all the wiry, gnarled and distorted branches, as well as the dead ones, must be cut away clean. All the stumps of branches which show little signs of healing over should be carefully dressed and the ends either tarred or plastered over with a well-kneaded mixture of soft earth and cow-dung. If, during the process of pruning, the branches get notched or otherwise badly lacerated, the ends should be carefully dressed to prevent insects killing the tree or water lodging in the cavities. A carefully pruned tree quickly sends forth a number of vigorous shoots, whilst a badly or carelessly pruned tree either dies or sends forth only weak, straggling, wiry branches. (Plate VIII, A). Strong growing plants should be lightly pruned, whilst old and decrepit trees should be headed back to induce production of new wood which renews the vitality of the tree. Heavy pruning should be followed by light pruning. In Northern India it has been found that heavy pruning of old and weak *ber* plants is required in the beginning. Thereafter no pruning, excepting that which is automatically done by the removal of the lac-bearing branches every season, is required for eight to ten years. It is true that the continuous propagation of the lac insect considerably lowers the vitality of the tree on which it grows, but this loss can be made up by judicious pruning which has the same effect as manuring. The photographs (Plates IX and X) show the stages in the growth of a heavily

pruned tree, which six months after pruning was ready to be inoculated. (The effect of pruning as well as the necessity for it depends upon the locality and the climatic conditions prevailing therein.)

Determination of emergence of larvæ from examination of the ovaries of female lac insects.

In the past much difficulty has been experienced in fixing the local dates of emergence of the lac insects. These dates, as is well known to those who are interested either in the cultivation or the manufacture of shellac, vary from place to place. In some cases the variation in the dates of emergence is so great that considerable difficulty is experienced in starting and finishing the work of inoculation in proper time and this has, in my opinion, militated to a great extent against the extension of lac cultivation. Had it been easy to foretell or to know with some certainty the dates of emergence of larvæ, the cultivation of lac, in my opinion, would have been more extended and varied than what it is now and the heavy fluctuations which are the order of the day would not have taken place frequently as is the case now. No doubt there are other and more important factors, which have a direct bearing on the production of lac, but this is also one of them, and as such, demands some attention. In the past the lac-growers have had to depend mostly upon their own past experiences or on the advice of the elders within the lac cultivating zone or villages. They have no definite data whereon to base their calculations and results, and it is no wonder that these calculations are extremely vague and unreliable. In the same locality or lac-growing zone, I have seldom come across two lac-growers agreeing with each other in their calculations regarding the probable date of emergence of the lac larvæ. The variations, when they do occur in such tracts or localities, produce no serious consequences, but now with the impetus that the industry has received of late, the cultivation is bound to increase not only in the localities which hold the monopoly of lac cultivation at the present time but in new and distant localities where the host plants of the various species of the lac insect occur in abundance, and signs at present are not wanting to show that the future augurs well and has great potentialities for the development and consolidation of the industry provided adequate precautions are taken to safeguard it.

These and such other considerations led me to find out some means whereby the emergence of lac insects could be determined with at least some degree of certainty. This step is essential in any scheme of extension of the industry and I may say here, that others before me have felt the necessity of finding out methods whereby the wastage of lac

larvæ, that is inevitable these days, could be appreciably, if not totally avoided. A writer early in the seventies remarked :—

"The failures that have attended the attempts to send seed-twigs from one part of India to another, have been due mainly to the fact that the seed-twigs were cut too long before the swarming period or too near it."

In places where the cultivation has been started for the first time there have been instances where through sheer ignorance the attempts have proved entirely unsuccessful owing to the subordinates having mistaken the exclusion of the males for the emergence of the lac larvæ. Almost all the lac-bearing branches were removed and carted, when it was detected at the last moment that a serious mistake was made. There are not only straggling records of such happenings but there is ample evidence to show that such occurrences are not uncommon in the lac-growing tracts even at the present time. No doubt, the ignorance and illiteracy of the masses is a serious obstacle to the adoption of new and improved scientific methods but, as in other spheres of life, where the cultivator becomes aware of some personal gain to follow by the adoption or relinquishment of a practice, it is expected that he will soon be convinced of the necessity of adoption of a better method for prognosticating the emergence of lac larvæ in his own plantation or in those of his neighbours. Some of the experienced Forest Officers too have felt the necessity of adopting a method which would do away with the uncertainty and fickleness in the emergence of the lac larvæ. Mr. Mckee (*Indian Forester*, Vol. I. p. 269, 1876), said :

"..... The next point to fix on is the local date on which the insects leave the parent cells, a step of great importance and one on which the first success of the plantation will very greatly depend ; should the work of gathering brood-lac be delayed until visual proof of the exit of larvæ is obtained, a vast quantity will be killed in the operation of collection transport and of tying the incrusted twigs on the standard selected nurseries."

Later on the same officer remarked :—

"....A knowledge of which will enable a large number of trees to be prepared during the working season than if it was necessary to delay the operations until evolution actually took place, as owing to the latter being barely simultaneous in and about one locality, the period for forming the plantation must be necessarily limited to the number of days it takes the cells to become empty, besides which, by attaching the lac twigs before the birth of larvæ great number are saved, which would otherwise perish during the process of being attached to the trees....."

In short, those who are doing the cultivation or those who are interest in shellac manufacture or those who are anxious to develop the dormant resources of their Estates or property to the full are really anxious to know of a definite and reliable method to fix the emergence of the lac larvæ in their own particular tracts. No doubt, there are methods by which the experienced lac growers approximately determine for themselves the probable date of emergence of lac larvæ. But as I have already said above, such rough and ready methods of determination could hardly be relied upon, especially when the cultivation has been started in an altogether new locality or is contemplated to be started in a new one. Thus with the impetus that the industry has received of late, it is probable that more localities will be opened up for lac cultivation and in consequence more brood-lac will be required to meet the growing demand. This will necessitate more accurate determination of emergence of lac larvæ than has been the case hitherto so as to facilitate cutting and transportation of brood-lac long distances either by rail, post or steamer.

The method advocated herein is not final, but it is the best hitherto known. An examination of the ovaries would give sufficient data wherewith to know the probable date of the emergence of larvæ. Repeated trials of the method have convinced me that it is the best until some other device may be hit upon to simplify the technique and to dispense with the necessity of costly instruments and accessories. From an examination of the accompanying table it will be seen that the method gives fairly accurate results. The error has not hitherto been found to exceed more than three days.

Determination of larval emergence on ovarian development.

Specimen Number	Broodlac	Date of emergence according to examination of ovaries	Actual date of emergence of larvæ	Remarks
1	*Ber* broodlac × *ber* . .	4th Aug. .	3rd Aug. .	One day early
2	*Ber* broodlac × *ber* . .	4th-8th Aug.	3rd Aug. .	Do.
3	*Ber* broodlac × *kusum* .	19th July .	19th July .	
4	*Ber* broodlac × *kusum* .	22nd-26th July	22nd July .	
5	*Kusum* broodlac × *ber* .	22nd July .	22nd July .	
6	*Kusum* broodlac × *ber* .	25th-29th July	25th July .	
7	*Ber* broodlac × *gular* (*Ficus glomerata*).	26th July .	26th July .	

Determination of larval emergence on ovarian development—concld.

Specimen Number	Broodlac	Date of emergence according to examination of ovaries	Actual date of emergence of larvæ	Remarks
8	*Kusum* broodlac × *ber*	28th July—4th Aug.	28th July	
9	*Ber* broodlac × *ber*	28th July—4th Aug.	28th July	
10	*Kusum* broodlac × *ber*	28th July—31st July.	28th July	
11	*Kusum* broodlac × *ber*	29th July	29th July	
12	*Ber* broodlac × *kusum*	2nd Aug.	2nd Aug.	
13	*Ber* broodlac × *ber*	2nd-4th Aug.	2nd Aug.	
14	*Ber* broodlac × *ber*	2nd-6th Aug.	2nd Aug.	
15	*Kusum* broodlac × *ber*	8-12th Aug.	6th Aug.	Two days early.
16	*Ber* broodlac × *ber*	22nd-26th Oct.	22nd Oct.	
17	*Ber* broodlac × *ber*	22nd-26th Oct.	22nd Oct.	
18	*Kusum* broodlac × *palas*	3rd-7th Nov.	7th Nov.	
19	*Palas* broodlac × *palas*	3rd-11th Nov.	7th Nov.	
20	*Kusum* broodlac × *ber*	28th Jan.-15th Feb.	17th Feb.	Two days late.
21	*Ber* broodlac × *ber*	8th-16th Nov.	12th Nov.	
22	*Palas* broodlac × *palas*	8th-18th Nov.	8th Nov.	
23	*Palas* broodlac × *palas*	8th-18th Nov.	8th Nov.	
24	*Palas* broodlac × *palas*	8th-18th Nov.	8th Nov.	
25	*Ber* broodlac × *ber*	12th-14th Nov.	13th Nov.	
26	*Palas* broodlac × *palas*	17th-21st Nov.	19th Nov.	
27	*Kusum* broodlac × *Ficus infectoria*.	18th-22nd Nov.	23rd Nov.	One day late.
28	*Kusum* broodlac × *Ficus* sp.	18th-26th Nov.	26th Nov.	
29	*Palas* broodlac × *palas*	18th-22nd Nov.	18th Nov.	
30	*Palas* broodlac × *palas*	19th-29th Nov.	24th Nov.	
31	*Palas* broodlac × *ber*	29th Nov.-4th Dec.	29th Nov.	
32	*Kusum* broodlac × *arhar* (*Cajanus indicus*).	15th-25th Feb.	17th Feb.	

The accessories required for this work are :—

A compound microscope.
A dissecting microscope or a Greenough's binocular.
A few clean slides.
A scalpel.
Two or three pipettes (one medium, one fine).
Three or four stout mountd, needles.
Three or four watch glasses.
Normal saline solution or distilled water.

The only difficulty that is likely to be experienced by most of the growers is that they cannot provide themselves with the equipment given above. The microscope and the dissecting microscope or the binocular require a very heavy outlay, far beyond the reach of an ordinary grower. But the method advocated above is more or less a laboratory method intended for those who have some knowledge of microscopic technique or are working in a laboratory fitted with the above things. All that is required is to take a few cells on a stick, remove the resin round the insects either with a scalpel or a teaser, make a longitudinal incision with a pointed needle, and take out a portion of the ovaries on a clean slide. The specimens are then washed either in normal saline solution or in distilled water, adjusted under the binocular and examined under the microscope. A comparison is then made with the figures in the accompanying plate, and the period determined for the particular locality from which the specimens have either been obtained or collected.

It should be noted that teasing out of the resin should be done expeditiously without unduly rupturing or squeezing flat the ovarioles under the dissecting miscroscope. After taking out a portion of the ovary on a clean slide, flush out the colouring matter with either normal saline solution or distilled water until the ova appear fairly transparent under the binocular. These should then be examined under a compound microscope, as quickly as possible, otherwise endosmosis takes place distorting the shape of the embryo within the eggshell. No alcohol is to come in contact with the ovaries, as they are soon distorted beyond recognition. An examination of the figures 1-4 on plate XI will show that the dark red ova have been adversely affected with heat in their various stages of development and as such fail to emerge. At first the head end of the embryo (Plate XI, fig. 9) is directed towards the posterior end of the egg, but as it advances in growth (Plate XI, fig. 10) after the appearance of the head and thoracic appendages, it turns round its transverse axis and moves up the oviduct (Plate XI, fig. 11). As

soon as it reaches the vaginal opening, the opening in the anal tube, it casts off the thin film enclosing it (Plate XI, fig. 12) and moves away in search of a succulent part of the stem to fix itself. A regular examination of the ovarian tubes according to process detailed above will show that all the ova are not in the same degree of maturity and this explains the reason why when once the emergence of young ones has begun, it goes on intermittently for over four to five weeks. This is an important provision of nature and had it not been for this the industry would have long since become extinct. If, on the day, the young insects swarm out there is a strong gale with rain, the majority of these are likely to be either blown away or washed off the trees. The succeeding lot of ova, which have been developing, mature and a subsequent swarming of young ones takes place. The rate of egress of larvæ depends upon the vitality of the brood-lac. The healthier the brood-lac the more vigorous the emergence and subsequent production of resin. This illustrates the necessity of selection and the adoption of methods in consonance with the present market requirements.

Life-history of the lac insects.

For successfully working lac, one must be familiar with the life history of the insect that produces the lac.

On examining a twig covered with lac one will find a number of resinous globules adhering closely to the stem and the presence of such globules is distinctly seen on the stick after the lac has been scraped off (Fig. 19). These are the full-grown females containing fertilized eggs. When the eggs mature, small, deep red insects come out of a hole situated at the posterior end of the body of the female and begin to wander about in search of suitable places to fix themselves. This happens twice in the year. Throughout the country the local dates of emergence of the tiny insects vary considerably according to the food-plant on which they grow and the climatic conditions prevailing in the locality. The following are the approximate dates of emergence of the young insects in the different Provinces :—

Province	Tree	Baisakhi crop	Katiki crop
1 Bengal—			
(1) Santhal Parganas.	*Kusum*	May-July	October-January.
	Palas and *ber*	March-May	August-October.
(2) Palamau	*Kusum*	July-August	October-January.
	Palas	May-June	August-October.
(3) Murshidabad	*Ber*	June-July	September-October
(4) Birbhum	*Ber*	March-May	September-October.

Province	Tree	Baisakhi crop	Katiki crop
II. Central Provinces	*Kusum*	July-August	December-February.
	Palas	June-July	September-November.
III. Assam	*Arhar*	May-June	October-November.
IV. United Provinces	*Palas*	June-July April-May (Bundelkhand)	October-November.
V. Punjab	*Ber*	May-June	October-November.
VI. Bombay (Sind)	*Babul*	April-June	November-January.
VII. Madras	*Jalla* (*Shorea talura*)	March-April	October-November.

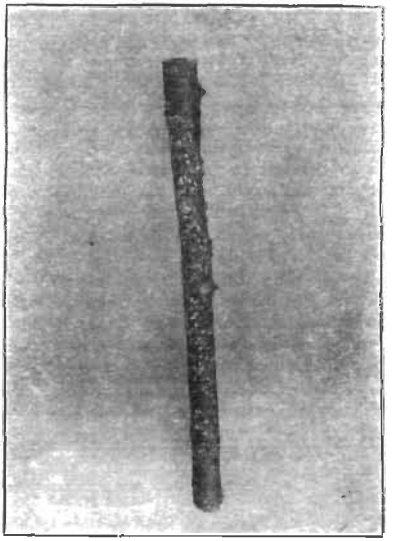


FIG. 19. *Ber* broodlac on *ber*. Cretaceous spots on a *ber* stick after removal of female resinous tests showing position of rostral setæ and post oral lobes. (Original.)

At the time of emergence the larvæ (young insects) are one-twenty-fifth of an inch long, deep red in colour, with three pairs of legs, a pair of

black eyes, a pair of feelers (antennæ) with a pair of long, thin hairs at the tip (Plate I, fig. 3), a small bent tube and a pair of thin hairs at the end of the body. They are very sluggish in their movements and wander about until they come upon a suitable spot to fix themselves. When once fixed they cannot be removed. They are gregarious in habit and have mostly been seen to move upwards and then to settle down on tender branches in places protected from the wind. At this time there is very little difference between the young male and female insects.

In the case of *ber* brood-lac on *ber* in the third week after fixation of larvæ on the branches, the anterior and the posterior spiracles became prominent, the perforations to brachial plate increase with seven nuclear ducts, the anal wing becomes formed of six plates, the anal setæ become ten, and derm pores appear in the oral and brachial regions. In the fourth week after fixation, transverse as well as marginal derm pores appear, the dorsal spine with its glands appears as well as the perivaginal pores. In the fifth week perforations to brachial plates, as well as, the nuclear ducts become more prominent than before. Derm pores appear in the oral and brachial regions, together with the marginal derm pores. At this stage the antennæ become considerably reduced. It is in the sixth week after fixation that the dorsal spine develops prominently in the majority of female larvæ. In the eighth week ovules develop and continue to grow, as can be seen easily by following the microscopic method given above. In the ninth week the supra anal plate becomes covered with setæ, when the resinous female test is full grown, translucent resinous globules appear laterally or a little upwards and these are considered by the lac cultivators, who cannot afford to possess costly microscopic equipment for diagnosing the growth of females, as signs of maturity, Fig. 22. In a number of female resinous tests on a stick there occur transverse cracks and these, together with the presence of translucent, resinous globules, are considered by the cultivators, as sure signs of maturity of the female lac insects within resinous cells. In some localities whilst the females are developing after fertilization, they become partially covered with *Cephalosporium* sp., associated with *Sporotrichium* sp., *Cladosporium* sp. and few other mould fungi. In one locality, a large number of developing females were seen to die and specimens of these were sent to Dr. T. Petch, Tea Research Institute of Ceylon, Nuwara Eliya, and he very kindly reported.

"The specimens of the lac insect sent by you were killed by a species of *Pythium*. I have a paper on this fungus in the press. It appears to be present in India, Ceylon and Java."

After fixation the larvæ thrust their beak into the tissues of the stem and begin feeding. The sap thus taken into the body is greatly transformed and is given out uniformly through pores all over the body in

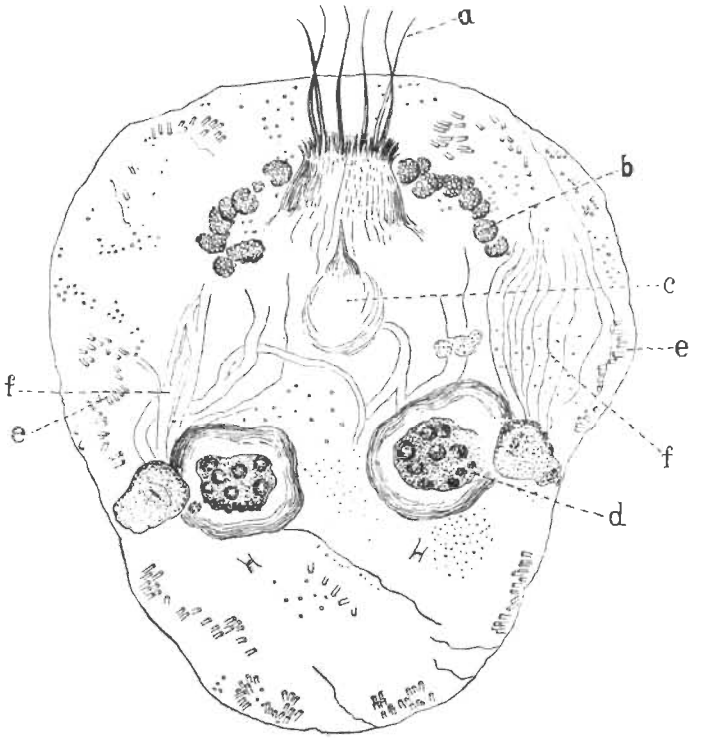


FIG. 18. *Ber* brood-lac on *ber*.

Female test twenty-four weeks after fixation of the female larva.

a. Anal ring seta.
b. Perivaginal pores.
c. Dorsal spine.
d. Brachial plate.
e. Marginal duct cluster.
f. Tracheal tubes.

(Original.)

the form of resin and wax, which after a few days, completely encases them. (Fig. 18). They then moult and begin to feed actively. If the young insect is a female it remains fixed once for all. If a male, there is a considerable modification of the legs, eyes, feelers and the anal tube. After a fortnight the male and the female larvæ (young insects) can be distinguished by the peculiar shape of their cells within which they remain incarcerated. The male cell (Plate I, fig. 7) is elongate, with a pair of holes at the anterior end from which thin whitish hairs come out. The female cell (Plate I, fig. 5) is nearly globular with an irregular margin, with three holes on the top—two situated at the fore part and the other at the hind part. From these holes, thin, long, whitish waxy hairs project, out of the resinous cell. Thus both the cells continue to grow until August (in the June inoculation) when wingless males come out. From the October inoculation both winged and wingles males emerge (Plate I, figs. 8 and 9). At this time the wingless males must not be mistaken for the young insects. On this point mistakes have been made in the past and are likely to be made again. Hence, to avoid such accidents, the following distinguishing characteristics between the two are given here (Plate I, figs. 3 and 8) :—

Young insect	*Wingless male*
a—One-twenty-fifth of an inch long.	*a*—Nearly one-twelfth of an inch long.
b—A pair of black eyes.	*b*—A pair of black divided eyes.
c—Feelers (antennæ) eight jointed, a pair of fine hairs at end of fifth joint.	*c*—Feelers (antennæ) eight jointed, joints nearly equal and hairy.
d—Abdomen indistinctly ringed.	*d*—Abdomen distinctly ringed into eight segments.
e—Legs delicate	*e*—Legs stout.
f—Tube at end of body indistinct.	*f*—Tube at end of body long, slightly bent apically.
g—A pair of thin hairs at end of body.	*g*—A pair of long, stout hairs at end of body.

In some places and at variable seasons the majority of the resinous cells on the plants are those of the males (Fig. 21). When this happens the encrustation is thin and the crop is poor. Whether this is due to the vigour of the tree on which the insects feed or to the periodic seasonal appearance in connection with the parthenogenesis, which prevails in the case of the lac insect or to deficiency of food supply, is not well understood in the particular case. This phenomenon I have seen to occur not only in the case of *ber* (*Zizyphus jujuba*) and *arhar* or *mirimah* (*Cajanus indicus*) but also in *Albizzia lebbek* (Fig. 21) and *Shorea talura* in Mysore. In the case of the latter, recently I found that when the *Shorea talura* brood-lac was put on *arhar* (*Cajanus indicus*) there

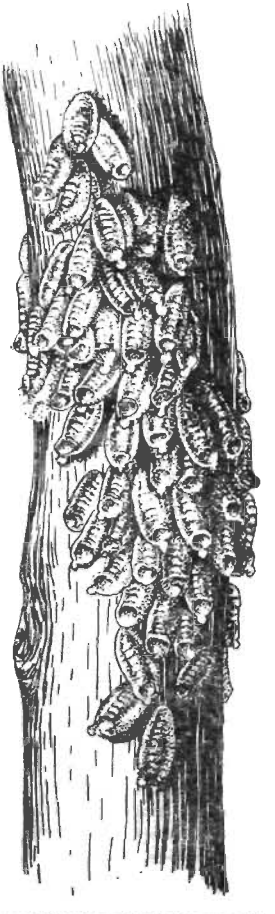


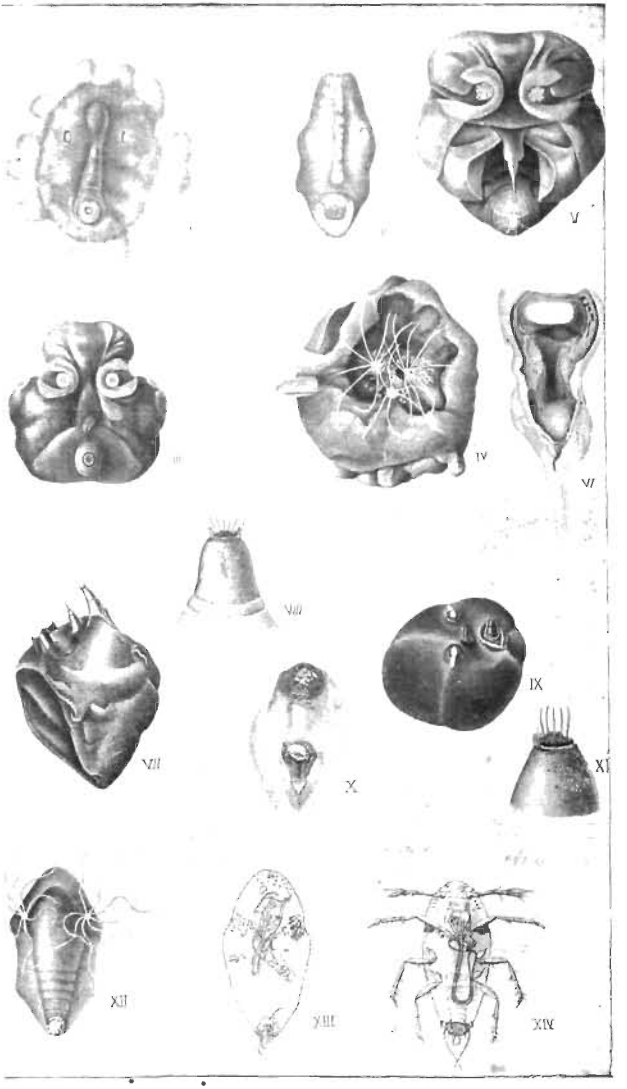
FIG. 21. Lac on *ber* mainly covered with male cells. (Original.)

too the majority of the encrustation consisted of male cells. In one instance at Bangalore, when *Loranthus* sp., growing as a parasite on a *Shorea talura* tree, became infected with *S. talura* lac, the majority of the cells in this case too were those of the males (Fig. 21).

In some places, especially those where the cultivation of lac has been started for the first time, the inoculated trees are frequented by ants* in large numbers to lick the honey dew excreted by the female insects through the anal opening (Plate XII, figs. 8 and 9). In such cases, the consensus of opinion is that the ants cause the death of the females within the resinous cells by breaking away the whitish filaments which come out of the three holes (the two posterior stigmata and the anal tube) and were supposed to be the elongations of the tracheæ (breathing tubes), Plate XII, figs. 4 and 9. The idea of the whitish waxy threads being tracheal elongations is erroneous. The threads consist of a particular kind of wax which is soluble in alcohol and alkali. When the ants walk over the female cells, as these lie either in a horizontal or vertical position according to the position of the stem on which they happen to be established, the waxy threads that come out of the anal tube, as well as the chitinous shields over the two posterior stigmata stick to their legs and are unconsciously broken off. At times, the ants, have been observed to bite off the threads with their mandibles and to lay the bits aside but close to the stigmata. The possibility is that parts of these threads, as well as the cretaceous wax lying at the mouth of the spiracular opening (Plate XII, fig 10) become consolidated into a compact mass thus blocking the spiracular opening and bringing about the death of the females within resinous cells through asphyxiation. If the resinous cells enclosing females within them be examined closely, the anal tube as well as the two posterior spiracular shields over the two posterior stigmata will be found to lie loosely within holes on the resinous cell. By the frequent passing of the ants, such holes become blocked with portions of cretaceous threads, unconsciously broken off by the ants in their attempts to lick the honey-dew, that, asphyxiation and subsequent dying off of the females takes place. Whether this is the only plausible explanation remains to be verified by a series of experiments intended to solve the debatable point. (Fig. 23). In some cases ants enclose lac insects in their nests (Fig. 24).

The wingless, as well as the winged, males walk sluggishly over the resinous cells fertilizing the females. After fertilization the females

* *Diacamma vagans*, Smith; *Cremastogaster subnuda*, Mayr.; *Polyrhachis simplex*, Mayr.; *Œcophylla smaragdina*, Fabr.; *Myrmecocystus setipes*, Forel.; *Camponotus mitis*, Smith; *Tapinoma melanocephalum*, Fabr. *Camponotus compressus* Fabr.



• Male puparium and development of the female test.

EXPLANATION OF PLATE XII.

Male puparium and development of the female test.

Fig. 1. Test of female—150-153 day after inoculation, ×32.
„ 2. Male puparium—150-153 days after inoculation, ×19.
„ 3. Test of female teased out of resinous cell—151-156 days after inoculation, ×32.
„ 4. Test of female—175-182 days after inoculation, ×32.
„ 5. Test of female teased out of resinous cell—175-182 days after inoculation, ×27.
„ 6. Basal portion of anterior stigmatic process of female test—(much enlarged).
„ 7. Test of female teased out of resinous cell—207-212 days after inoculation, ×72.
„ 8. Anal process of females—207-212 days after inoculation—(much enlarged).
„ 9. Test of female teased out of resinous cell—238-243 days after inoculation, ×10.
„ 10. Anterior stigmatic process of female—238-243 days after inoculation—(much enlarged).
„ 11. Anal process of female—238-243 days after inoculation, ×27.
„ 12. Test of female—58 days after inoculation, ×32.
„ 13. Test of female teased out of resinous cell—58 days after establishment, ×32.
„ 14. Male puparium (ventral view)—58 days after inoculation, ×47.
„ 1—11 are of lac on *ber* (*Zizyphus jujuba*).
„ 12—14 are of lac on *kusum* (*Schleichera trijuga*).

Fig. 23. One of the posterior breathing holes of the female lac insect showing ramification of air tubes—from below. (Original.)

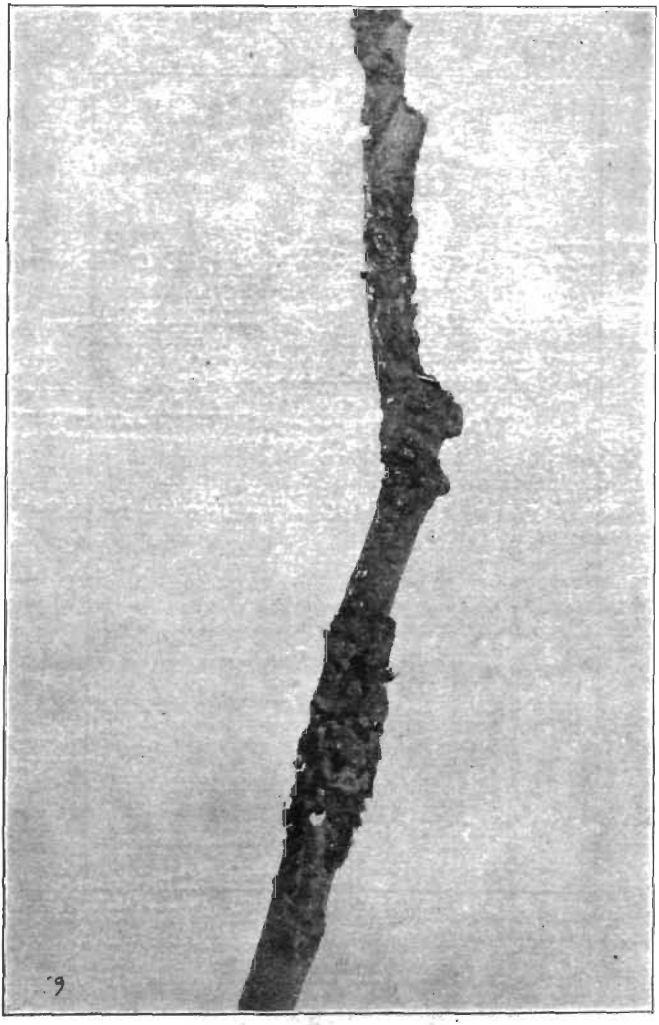


FIG. 24. Lac on *Nephelium litchi* within ant nests. (Original.)

develop fast. They take in more sap, consequently exude more resin and swell up. When fully matured the final size of the adult female is many times larger than the early adult female. To accommodate the increased size of the female the resinous test also expands proportionately and it is said that the heat of the sun induces the necessary plasticity to the resinous envelope. Others have explained that the unusual glands attached to the dorsal spine pour out a special secretion which softens the resin thereby permitting expansion of the resinous test. But to me it appears likely that the secretion by the special marginal ducts renders the resin plastic thus facilitating its increase in size according to the growth of the female lac insect within, Fig. 22 and that the special musculature of the female lac insect (Fig. 20) strengthens this view. At this time a copious amount of sugary liquid—technically known as "honey-dew"—is excreted and this, falling on the leaves, branches and the ground below trees, develops a black fungus. The waxy hairs lengthen out and the branches covered with lac appear white from a distance (Plate XII, fig. 4). If, however, the characteristic whiteness is not seen, it is to be feared that the females have been killed either by heat or by parasites. Normally the female continues to grow for eight months and a half in the October inoculation and for three months and a half in the June inoculation. Three weeks before the emergence of the larvæ she ceases to feed and her body shrinks as eggs are laid. If, therefore, the lac-bearing branches be cut a fortnight before the coming out of the young ones no harm is done to the brood-lac on the branches of trees. This fact is of great use in sending brood-lac to distant places by post, in arranging exchanges of brood-lac from different places and in carrying out the inoculation of trees on a large scale. When the young insects again swarm out, they wander about from 12 to 20 hours or even more and then settle down on the branches. The emergence continues for over five weeks, but is at its height during the first three weeks.

Life-cycle throughout the year.

In Northern India the life-cycle of the lac insect is approximately as follows :—

Starting with the *Baisakhi* (summer) crop the young insects swarm out by the middle of June. On coming out they wander about and ultimately fix themselves on the tender branches and begin exuding the resin which completely surrounds them. At first there is very little difference between the young male and female insects, but a fortnight after fixation the cells containing them become distinguishable. The male cell is elongate, the female cell is roundish. Both continue to

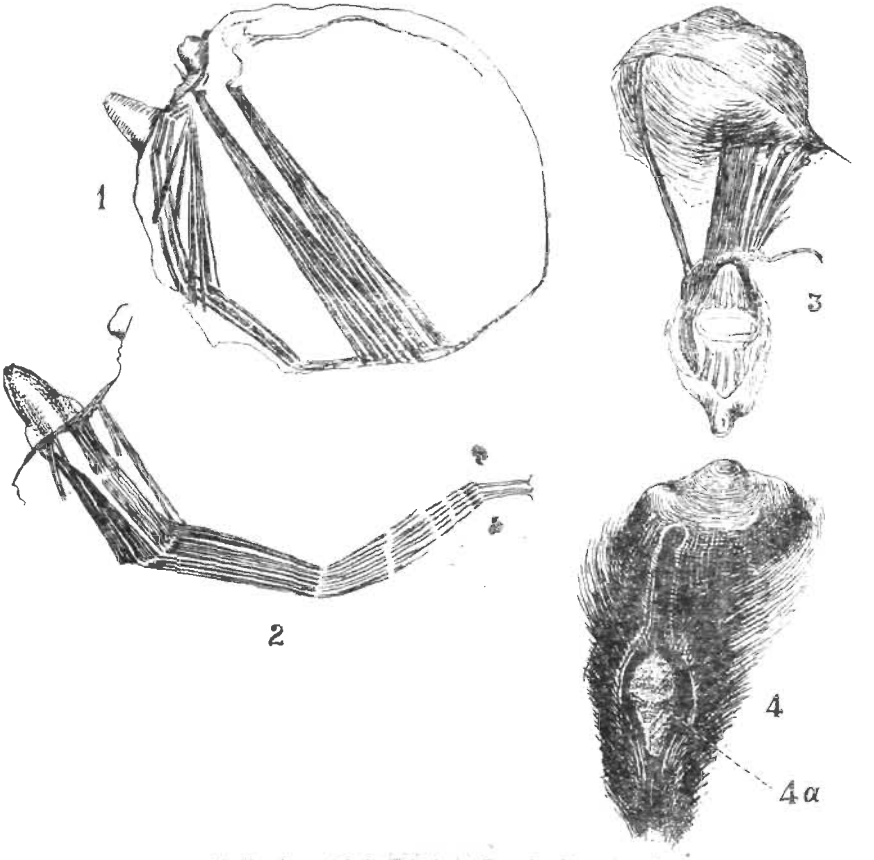


FIG. 20. Musculature of the female lac insect (*Kerria* brood-lac on *kusum*).

1-2. Musculature of adult female.
3. Musculature of brachium and the brachial plate.
4. Right anterior spiracle dorso-laterally.
4a. Spiracular opening.

(Original.)

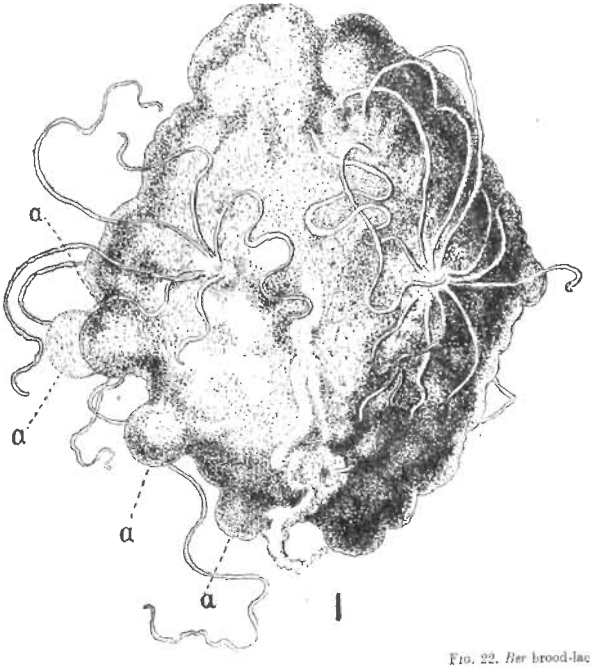


FIG. 22. *Ber* brood-lac on *ber*.

1. Female test fully matured.
1*a*. Globular, translucent, resinous accretions to the female fully matured test. × 60.
2. Mature female treated with cool caustic potash 8 per cent. showing marginal duct pores with waxy threads. × 30.
(Original.)

grow until August when the wingless males emerge. These fertilize the females and die. The female then begins to grow rapidly takes in more sap and exudes more resin. Thus she continues to grow until the middle of September when she stops feeding, lays eggs and continues to shrink until she also dies. (Plate XIII).

By the beginning of October the young ones again swarm out and continue to do so for five weeks. After wandering about for some time the young ones fix themselves, suck the juice and the resin and wax are then given out through pores all over the body and surrounds them completely. By the end of January wingless, as well as winged males emerge, fertilize the females and die. The female thereafter continues to grow until the beginning of June and then dies. The young ones then again come out by the middle of June and thus complete the life-cycle throughout the year.

Preparations prior to inoculation.

The first and most important point to know in lac cultivation is the local date of emergence of the young insects. In Northern India the local dates vary from place to place, as has been mentioned above. The best way of knowing these in different places is to follow the directions given on page 34 and to observe the emergence during the year from May-August for the *Baisakhi* (summer) crop, and from October to January for the *Kartiki* (winter) crop. Having once determined these, they will be found to remain fairly constant for the locality from year to year. The next thing is to cut the lac-bearing branches a fortnight before the probable emergence. This enables one to inoculate a large number of trees, to exchange brood-lac from distant places, and to sell the remainder not required by the lac-breeder for his own use.

If a large number of *ber* trees are to be inoculated, a fortnight before emergence is the most convenient date for cutting the brood-lac. If a smaller number of *ber* trees are to be inoculated, the cutting may be deferred until a week later. To remove the lac-bearing branches a man goes up the tree with a long, straight, sharp knife (Plate XIV, fig. 1) and cuts the branches (Plate XIV), making clean cuts only, and dressing the ends of those which accidentally get notched or otherwise lacerated. Another cooly stands below the tree and removes such portions of the branches as do not bear any lac. Having dressed the branches, he, passes them on to a third cooly who sits near the tree and cuts them into lengths of 8 to 11 inches with the outer blade of the heavy bent knife (Plate VII, fig. 3). In cases where large areas are to be dealt with this is not necessary. While cutting he also examines the lac-bearing branches, and if any are found damaged or containing predaceous cater-

LAC ON *BER*.

On the left a twig, showing the young settled down shortly after inoculation. In the middle, half-grown healthy lac showing the characteristic white fluffy appearance.

On the right, mature lac from which the young have emerged. In the middle, is a single hole from which has emerged the moth of a caterpillar that feeds on lac. (All natural size.)

MAN CUTTING DOWN LAC-BEARING BRANCHES.

pillars he keeps them aside. When all the branches have been collected and cut into lengths of 8 inches to 11 inches, they are taken home and spread on rows of bamboos to aërate in a cool, airy place, preferably the varandah of a house.

In case where a large number of trees or a large area is to be inoculated, all that is necessary is to cut the brood-lac branches a week to a fortnight before swarming and to examine them. Such branches as contain a large number of holes of the exit of the predator moth *Eublemma amabilis* (Fig. 14) or the encrustation on them is poor (Plate XVI. B), should be sorted out and not utilized for purposes of inoculation. The resin from such stems should be scraped off and, washed in water to remove the colouring matter—technically known as the lac-dye—which should preferably be spread on the fields and incorporated with the soil. Only healthy branches should be utilized for inoculating fresh trees. (*Plate XVI, A*).

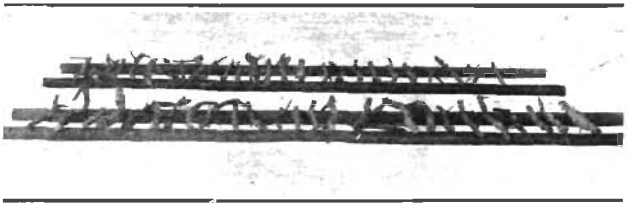


FIG. 25.
Brood-lac sticks aërating on bamboos.

If, however, only a few trees are to be inoculated, the sticks should be occasionally examined and turned over to aërate them well. Twelve to fourteen days after, when a few, tiny, deep red insects are seen crawling over the sticks, they are taken to the trees already pruned for the purpose and tied to their branches either with plantain bast, jute or *sann*-hemp fibre or any other cheap fibre. When large *ber* trees are to be inoculated it is found convenient to haul up the sticks in *shikias* (Fig. 15). In inoculating a number of *palas* trees, it is not necessary to cut the lac-bearing branches into pieces. All that is required is to cut off the branches a fortnight before the emergence of the young insects, and to remove such portions thereof as do not bear any lac. Having done this the branches are either to be kept for a day or two in a cool, shady place to aërate or put directly on to fresh trees. By cutting the branches

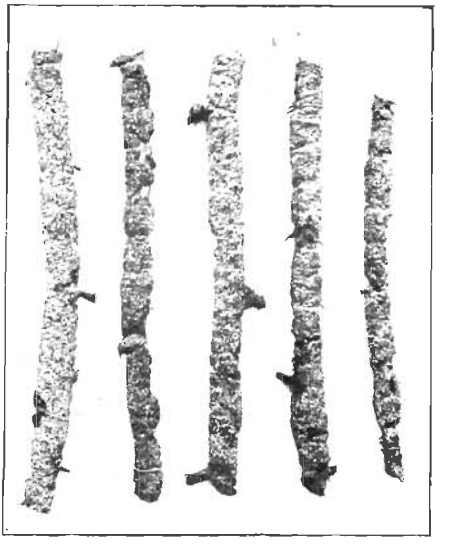
just when the young insects are seen crawling over them much of the brood-lac is lost, as the ends of branches being then green, the insects fix themselves there and are thus lost. Where labour is dear, bamboo receptacles (Fig. 16) will be found very convenient for putting on the brood-lac over a large number of *palas* and *ber* trees. They can easily be made locally and can be had at twelve annas per hundred, or even cheaper if obtained in numbers. Each receptacle consists of 12 to 16 slips of bamboo; each slip is 32 inches long and ¾ of an inch broad. They are loosely woven at the bottom and again at 7 to 8 inches from the top—which remains open. Twelve to fifteen brood-lac sticks are put in each receptacle, and five, eight, ten, fifteen or even twenty of these are easily put on the *palas* trees according to their size. (Plate XV.) Before putting them on, their mouths are tied with string and another small piece is attached at the bottom to keep them in position. When the larvæ hatch out, they easily pass through the string to the branches and fix themselves there on the succulent portions. When the emergence is at an end, the receptacles are removed, the sticks taken out and the lac scraped off.

Inoculation of trees.

Inoculation is the process of tying brood-lac sticks to the branches of pruned trees in such a way that their ends touch the branches. This is usually done either ten to twelve days before the emergence of the young insects or when they have actually begun to swarm out. The object of doing this is to transfer the young insects from the brood-lac to the tender branches of the pruned trees where they fix themselves and begin exuding resin. In the days when prices for sticklac were high, and lac-dye (colouring matter obtained by washing the sticklac with water) was a marketable product, the growers used to collect almost all the lac before the emergence of the larvæ so as to get the largest quantity of lac-dye, and in consequence very little brood-lac was actually left on the trees for the following crop. This led to a heavy loss in the quantity of brood-lac available for seed and a state would soon have been reached when lac would have become scarce, had it not been for the aniline colours which totally displaced the use of the lac-dye as a colouring agent. Now with the fall in prices, the cultivator's attention should be drawn to preserving sufficient quantities of brood-lac and to improved methods of cultivation, which should result in the production of the better quality of lac required by the consumer. The first and most important point is to obtain and use only healthy brood-

A. *Palas* tree inoculated with bamboo receptacles.

PLATE XVI.



A. Healthy brood-lac sticks.

lac and to reject such as has been damaged by ants, heat, predaceous caterpillars and parasites. (Plate XVI).

Having done this, the next point is to attend to the details of inoculation. Only so much brood-lac should be put on a tree as may be able to grow on it successfully. To inoculate a tree heavily is to kill it and thereby loose the brood-lac. The sticks should be tied to branches with plantain bast, jute or sann-hemp fibre in such a way that their ends touch the branches. This is done in three ways :—

Firstly, Putting a brood-lac stick on each branch in such a way that its ends touch the branch.

Secondly. Tying a stick to three or more branches in such a way that it passes through two or more, and that its ends touch the two terminal branches.

Thirdly. Fastening a number of sticks at the base of a branch and tying them with thread or some fibre in such a way that the ends of sticks touch the stem both ways.

If, however, the sticks get loose, they must be tied again as before, and when, two to three days after inoculation or a little later, the branches appear red from below, the sticks are to be removed and fastened to other pruned trees. Not more than half the lengths of branches are to be allowed to be covered by the young insects. If this is not attended to, the trees suffer from over-inoculation and a poor crop is the result. With a large number of insects on them the branches are unable to respond to the drain on them and they wither prematurely. In some cases when the brood-lac is very healthy the emergence of the young insects is so profuse that within a few hours the greater portions of the branches become red. When such is the case the brood-lac sticks should be removed promptly and put on to other trees kept pruned for the purpose. This is to be repeated till the emergence ceases, when the sticks are to be removed and the lac scraped off. The young insects continue to emerge for over five weeks, but they generally come out in numbers during the first three weeks; afterwards their number rapidly declines. Such being the case, if at the time of inoculation it be raining, or a strong wind be blowing, it is safe to postpone the work until such disturbing factors cease altogether or their force is lessened. It is no good inoculating the trees while it is raining as then the young insects are liable to be washed off the trees. From experiments it has been found that if five *ber* trees are inoculated during September-October they will yield sufficient brood-lac during the following June to inoculate 25 to 30 trees.

Cycle of pruning and inoculating.

When only a small number of *ber* or *palas* trees is to be utilized for growing lac, it has been found advantageous to prune them carefully at a time when they are dormant and to inoculate them with healthy brood-lac obtained locally. It is no good pruning half the tree and allowing the lac to remain on the other half. By doing so the vitality of the tree suffers and the predators, as well as the parasites, increase in numbers. In some parts of Bengal, especially the Bankura District, the Sonthal Parganas and the Kolhan in Bihar and Orissa, the cultivators inoculate their *ber* trees in October-November and allow the crop to remain on the trees until the following October when they remove the crop. By doing so, they allow the predators—especially *Eublemma amabilis*—and the parasites to breed unmolested during June-July and to affect the crop in the following October. Those who know from experience what a serious pest *E. amabilis* is to lac cultivation and extension will condemn this obnoxious practice and insist on the cultivators to give it up entirely. (Figs. 26-27). By doing so they unconsciously do immense harm to the industry without in the least profiting themselves to any appreciable extent. It is not that they do not know the damage done by the moth, but out of sheer regard for the practice prevalent in the particular tract they inhabit that they carry it on as a mere routine work. But now with the increase in the price of lac it is advisable either to give up or modify the local practices to such an extent as not to restrict the output and the first malpractice that has crept into the routine of lac cultivations is the practice of allowing the crop of one season to remain on the trees for one or two seasons even successively. This should be stopped at once and, instead, the practice of clean removing one crop and carefully dressing and pruning the trees should be followed. Now that lac is a very valuable commodity, attempts should be made to concentrate the cultivation in such a way as to produce the maximum quantity per tree without impairing its vitality and preventing theft. This could only be done by starting fresh plantations of *ber*, *palas* and *kusum* in suitable localities. Within the last twentytwo years that I have been engaged in this work, I have not as yet come across any locality, in any part of India, where intensive cultivation is done and where the cultivation is concentrated within the limits of proper and adequate supervision. If, even now, fresh plantations of *ber*, *palas* and *kusum* are started in suitable localities, ten to fifteen years after a fairly decent income would be derived and a great portion of the waste land capable of bearing *ber* and *palas* would be utilized. Soil erosion would be stopped and the circulation of sub-soil water would be better regulated than now. The water level in the wells would rise or

remain fairly constant, the flow of water in the rivers would be better regulated and the tract, where such plantations would be started in good numbers, would be less liable to failures of rain. The question is worth considering from an economic point of view and it would then be found that the frequency of famines would be considerably lessened. The *ber*, as well as the *palas*, grows well in light loam and even in laterite soils. A

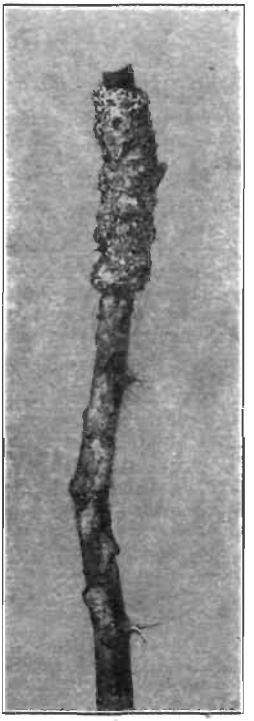


FIG. 26. *Kusum* brood lac on *ber* showing destruction of female tests by *Eublemma amabilis*. (Original.)

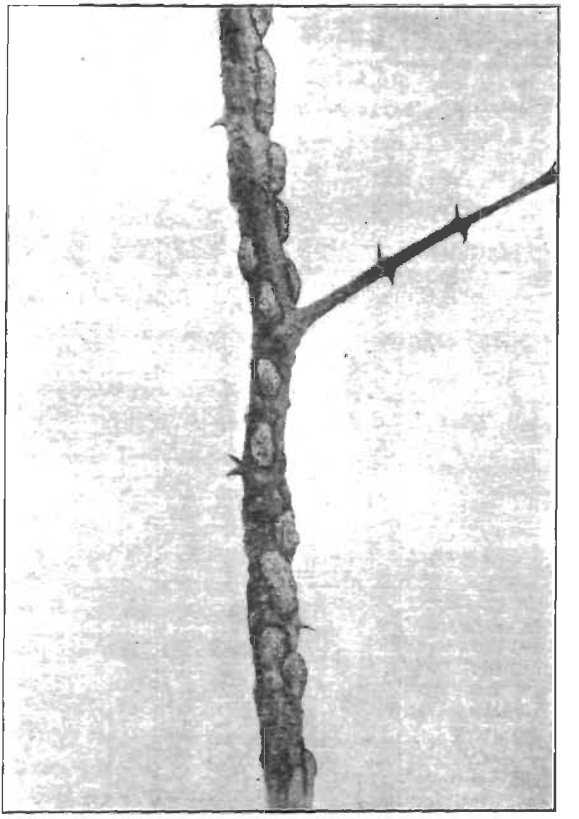
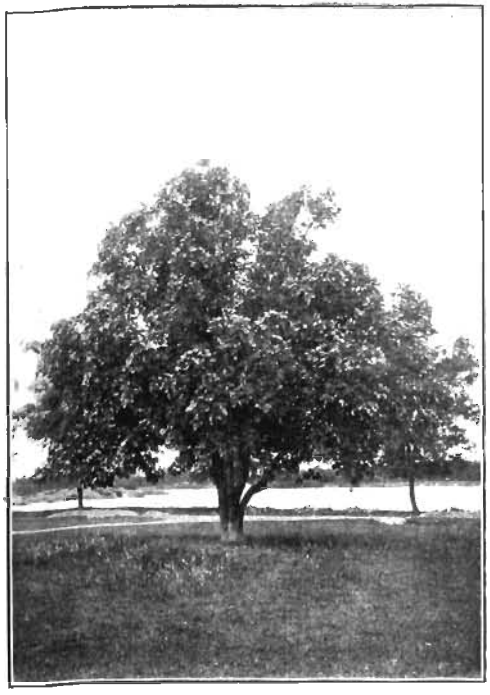
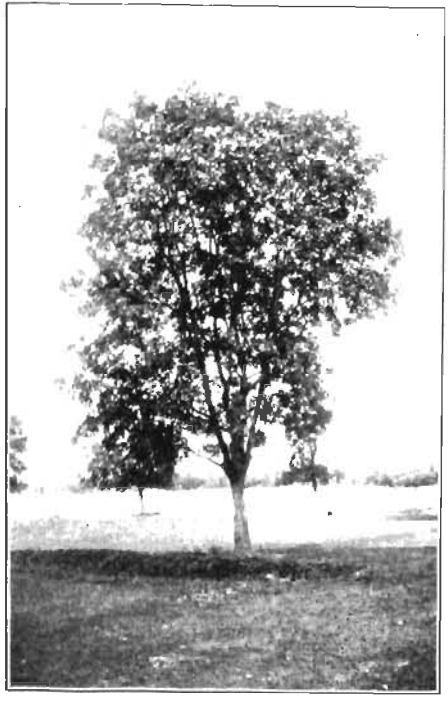


FIG. 27. *Kusum* broodlac on *khair* (*Acacia catechu*) showing destruction of female tests by *Eublemma amabilis*. (Original.) All the lac has been destroyed. Only the cocoons of the predator are left on the stick.



Palas.



Kusum.

Palas and *kusum* trees in light loamy soil at Pusa—16 years old. (Original.)

few *palas* trees, grown in the light loam of Pusa, were perfectly healthy and thirty to forty feet high sixteen years after planting. The girth of trees, flush with the ground level, varied from 4 feet 8 inches to 5 feet 10 inches. *Kusum* trees also planted at the same time and close to *palas* trees, were thirty to forty feet high and the girth of stems varied from 3 feet 10 inches to 4 feet 4 inches. (Plate XVII). If such trees are planted *en bloc* it would be advisable to divide them into convenient coupes or groups, so as to give rest to the trees and to facilitate supervision. A block of fairly good-sized trees may be divided into three coupes and, by a judicious system of rotation, fairly good crops would be obtained without impairing the vitality of the trees. The trees should be well spaced so as to allow air and sunshine to enter the rows of trees and if the soil be not altogether sandy, a catch crop of millets or low-growing leguminosæ, such as *moth* (*Phaseolus aconitifolius*), *masur* (*Lens esculenta*), *khesari* (*Lathyrus sativus*), *kulthi* (*Dolichos biflorus*) or *guar* (*Cyamopsis psoralioides*), may be taken off the ground between the rows of trees. If *palas* trees be planted 20 feet each way, 130 such trees would occupy an acre, leaving a small space for a footpath. If, however, the trees be spaced 22 feet apart, which I think is the optimum space for this tree, 110 such trees would occupy an acre. In the case of *ber* trees they should preferably be 30 feet apart each way; 63 such trees would fill up an acre, leaving a space which could conveniently be utilized for a footpath. If a cultivator could manage to obtain lease of ten acres of land he should divide the whole plantation into three compartments. By a judicious system of rotation he could obtain crops from two compartments and give rest to trees in the third compartment. The rotation would be somewhat on the following lines:—

A	B	C
Crops— June-October 1922. October 1923-June 1924. rest— October 1922-October 1923.	Crops— October 1922-June 1923. June-October 1924. rest— June 1923-June 1924.	Crops— June-October 1923. October 1924-June 1925. rest— October 1923-October 1924.

A. Prune February 1922 . . . . . Inoculate June 1922.
Prune June 1923 . . . . . Inoculate October 1923.

B. Prune June 1922 . . . . . Inoculate October 1922.
Prune February 1924 . . . . . Inoculate June 1924.

C. Prune February 1923 . . . . . Inoculate June 1923.
Prune June 1924 . . . . . Inoculate October 1924.

By having the trees concentrated into compact areas the work of *inoculation*, supervision and collection would be very much lessened than when the trees are scattered about. As suggested above, it is not absolutely necessary that the trees in compartments should get rest yearly or biennially. In some places, I have seen that where the roots of *ber* trees had struck a clayey bed of fairly porous texture, they stood pruning and inoculation well. But in places where they had found a rocky or impervious bed of clay, they required rest and stirring of the soil before they became fit to be inoculated. The system of rotation, in cases like these, should be regulated according to local climatic conditions and the kind of soil predominant in the locality.

Cost and yield.

No accurate figures as to cost and yield can be given, as wages and prices of brood-lac have risen considerably since the last edition of the bulletin was published. The lowest price was touched in October 1914, but from March 1916 a steady rise in the price of shellac continued until February 1920 when the maximum was touched. Thereafter, there was a fall in prices, but they still remained at a remunerative figure, with the result that the *Thikadars* (lease-holders) revived their leases and the cultivators, in the Zemindary areas, began to grow and collect lac. In some places, as already mentioned above (p. 11), an economic displacement took place, which had a disquieting effect on the industries displaced. One such thing was the silk industry of Murshidabad. People who were engaged in rearing silkworms gave up the industry as precarious and took to growing lac as a more paying business proposition. The result was that brood-lac could not be easily procured in the local markets. Those who used to sell it in the local *hats* gave up doing so and reserved the whole of the brood-lac for their own use. The result was that prices of brood-lac became prohibitive, and those who wanted either to start afresh or to extend their cultivation could not find enough brood-lac to do so. In May 1922, when shellac was being quoted at Calcutta at Rs. 182 a maund of 82 lb. brood-lac was not to be had at less than Rs. 3—Rs. 4 a seer inclusive of woody portions on which there was no lac. It is for this reason impossible to give accurate figures even in a single locality. In addition to the cost of brood-lac, labour too has become very dear. In places, where ample, though untrained labour was always available, there has become such a dearth of it that not a few zemindars, who have been growing lac for more than a decade are seriously thinking of curtailing their work. Another trouble is that within the last twentytwo years I have not come across a single locality where lac cultivation has been done on scientific lines and

continuously. The efforts in the past have been more or less spasmodic, depending largely upon the erratic conditions of the shellac markets in London and New York. When the prices fell, leases were either given up or the collections were limited, but with a little improvement in prices a scramble was made to collect as much as could be done in the forests, etc. All that I have been able to get at is that an average of four to six maunds could be expected of an acre under *palas* trees, provided these are carefully pollarded at proper time and inoculated with healthy brood-lac. In places where regular cultivation is done on *ber* (*Zizyphus jujuba*), a tree with twelve to sixteen inches in girth and with a good canopy, yields from four to ten seers, though in exceptional cases a yield of 3 maunds of stick-lac has been obtained from a single tree.

The important centres of lac cultivation at present are :—

Assam	Kamrup, Goalpara and Nowgong Districts. The Khasi, Jaintia and Garo Hills.
Bengal	Dhulian, Protapganj (Murshidabad district), Birbhum District, Bankura and Malda.
Bihar and Orissa . .	Singhbhum, Manbhum, Palamau, Ranchi, Hazaribagh, Lohardaga, Santhal Parganas, Gaya, Sambalpur and Mourbhanj State.
The United Provinces . .	Part of Mirzapur and Saharanpur Districts.
The Punjab . . .	Una Tahsil (Hoshiarpur District).
The Central Provinces . .	Damoh, Jabbalpur, Saugor, Hoshangabad Bhandara, Chanda, Raipur and Bilaspur Districts.
Native States . . .	Rewah, Panna, Chhatarpur, Maihar and Bhopal.
Bombay	Sind.
Burma	Northern and Southern Shan States and Karenni.

Out of the above areas, rapid developments have taken place in the Central Provinces and Bihar and Orissa. In the latter province, forty years ago the total produce was not more than two thousand chests, whereas more than fifty thousand chests of shellac are now obtainable from this area which is especially adapted for extensions of lac cultivation for the reason that it contains one of the favourite food-plants of the lac insects—the *palas*—in large numbers. The soil and the climatic conditions are both favourable for the development of the host as well as the parasite—the lac insect. The people are well versed in the technique of cultivation and a large number of shellac factories are situated within this area—those at Ranchi, Jhalda, Thulin, Purulia, Balarampur, Pakur, Kotalpokhar, Daltonganj and Imamganj. If definite and determined efforts are made to extend the cultivation in this area only a supply could easily be obtained which would be able to meet three-fourths of the world's total consumption of shellac. Such plantations, either of *ber* or *palas* or mixed, could be started now and

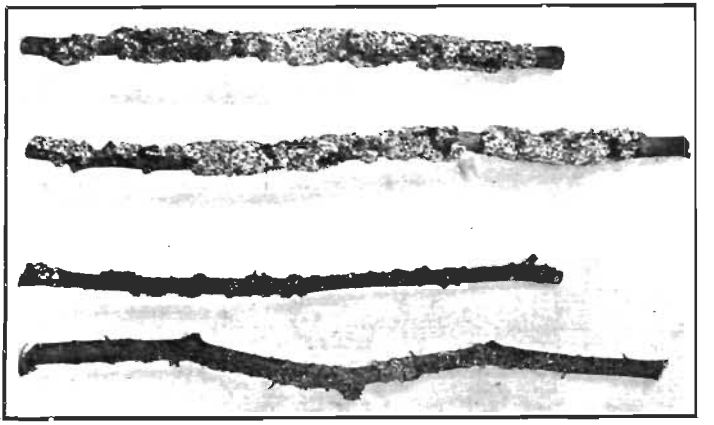
these, after a lapse of nine to twelve years, could be utilized for lac production. If the trees are planted at a distance of 20 to 22 feet each way, the intervening space could be utilized for taking a catch crop of either maize or *arhar* (*Cajanus indicus*) in favourable years when the rainfall is good and well distributed throughout the year. If, however, rows of *mahua* (*Bassia latifolia*), the future motor tree of India, are laid between the plantations, these would not only yield sufficient *mahua* flowers to be ultimately distilled into cheap motor spirit, but would yield timber useful for agricultural requirements. These trees, when well established, would mitigate to a certain extent the force and the effect of hot winds which generally blow in this area during May and June. Since *mahua* is a slow-growing tree, *karanj* (*Pongamia glabra*), *peepal* (*Ficus religiosa*), *sissoo* (*Dalbergia sissoo*) and *neem* (*Melia azadirachta*)or some such fast growing trees could be planted instead. *Karanj* grows well in the dry laterite soil of the area, and yields a low grade oil chiefly used for burning.

In an acre there could be planted 130 *palas* trees twenty-two feet each way, leaving a space which could be utilized for starting a nursery to fill in the blanks as they occur in course of time. To inoculate these trees, the cost varies between Rs. 30 to Rs. 40 when labour as well as the brood-lac are to be paid for. In the second year the cost would be reduced by one-third at least, representing the cost of brood-lac which originally had to be bought, but which in the subsequent years would be obtained from the plantation. It is, however, advisable to divide the plantation into three coupes or compartments and to work these in such a way that rest is given to the trees in the three coupes by turns. Such a system would keep up the vitality of the trees and would be found to pay well in the end. The produce from an acre of *palas* trees has been found to vary from four to six maunds in the Central Provinces, and taking the lowest produce per year as the average, the outturn would fetch Rs. 280 to Rs. 300 at the present time when the shellac quotation at Calcutta is Rs. 182 per maund (25th May, 1922). But these are abnormal prices and are not to be taken as standards of calculation in any well thought out scheme of cultivation. The safest average rate per maund could be taken at Rs. 30 which would thus leave an ample margin of profit for his labour and investments. The question is at least worth considering from a co-operative point of view, where a definite number of villages would only confine themselves to propagating and selling healthy brood-lac to the cultivators in the neighbourhood.

In the case of *ber*, the system in vogue in the Raghunathganj Subdivision of the Murshidabad District in Bengal, and the Kolhan in the Singbhum District in Bihar and Orissa, is worth consideration. In the former, the cultivators grow *ber* trees on their field embankments. They

PLATE XVIII

A. Men scraping *her* lac.



B. 1 and 2. Brood-lac sticks free from caterpillars. 3 and 4. Brood-lac sticks infested with caterpillars.

pollard them carefully every year and inoculate them either with brood-lac obtained from their own trees or buy the required quantity in the local *hats*. It is really a sight to see rows of vigorous tall trees growing with a good canopy on the field embankments for miles together. When the insects begin to swarm at one place, the news spreads fast from village to village and great activity is visible in the area. Cultivators are then to be seen either dressing up their trees, prior to actual inoculation, or hurrying up from *hat* to *hat* in search of brood-lac. A good sized *ber* tree is known to yield from two seers to half-a-maund. In a work of this kind the great advantage is the simplicity of the work, the inexpensiveness of materials required to start and carry on the work, and the non-interference it causes to the agricultural operations of the tract throughout the year. To grow lac on twenty *ber* trees does not take more than a week in both seasons, and the profit by the sale of the produce from trees on the home farm of the cultivator is sufficient to enable him to at least pay off his rents and thus to reserve the produce of his land entirely to himself. In the Kolhan in the Singbhum District, each *kol* has from four to ten trees round about his hut. These he pollards carefully every year and inoculates them with brood-lac bought locally. He is thus able to gain something out of the otherwise useless trees. He is thus able to utilize the wasteland round his hut and occasionally, when prices are high, he is able to obtain sufficient money wherewith to have occasional bouts of his favourite drink, the *Handi*.

Scraping lac.

When the young insects have ceased to emerge, the sticks bearing lac encrustations are removed, brought home and the resin scraped with knives (Plate VII, Figs. 4 and 2) in the case of *ber* lac (Plate XVIII). For *palas* and *kusum*, the resin easily comes off if twisted with the hand and no scraping with knives is required. If, however, the lac-bearing branches have remained unscraped for long, the resin is easily taken off by crushing the sticks with a *dhenkli* (Chunam grinding mill), care being taken that the resin is not ground too fine. As far as possible, the resin should be scraped off immediately after removal of the sticks from the trees, otherwise caterpillars spoil it and render it useless for commercial purposes. The scraped material—commercially known as stick-lac—should never be exposed to the sun as then the edges of the cells are likely to melt and turn over, forming compact masses—which is commercially known as agglutinated lac or blocky-lac—from which the cost of removing the dye is considerably increased. It should not be kept also in gunny bags after scraping, as then the heat of fermentation spoils the resin and lowers its marketable value. As far as possible

the stick-lac should be sold after scraping. If this be not possible, it should be washed, the seed-lac stored and the lac-dye used as manure.

Adulteration of stick-lac.

When prices are high, there is a great incentive to unscrupulous dealers to adulterate the stick-lac. This I have seen to be especially bad in the Dhulian and Protapganj lac-growing tracts in the Murshidabad District. The people generally put out the stick-lac in the sun and when sufficiently hot sprinkle fine sand over the material and rake it frequently. The hot sand sticks fast to the resin and renders it unfit for the manufacture of shellac. They also scrape very fine the bark of *babul* trees (*Acacia arabica*), moisten it with water and sprinkle it over stick-lac which is constantly raked until the adulterant is fully incorporated with it. *Mahua* seed, ground fine, as well as block salt are also used as adulterants. The only way to stop these malpractices is either to buy seed-lac from the cultivators or to penalize them by refusing to buy their produce until they give up their pernicious habits. With a little determination on the part of the manufacturers, the practice is bound to disappear very soon.

Storage of stick-lac.

The present system of storing stick-lac is open to serious objections. It not only deteriorates the quality of resin by long storage under unfavourable circumstances, but encourages the breeding of harmful insects, especially *Holcocera pulverea*, in enormous numbers. In several instances, I have seen godowns simply swarming with it. The direct effect of such a system may not be felt in a place like Mirzapur which is far away from the centre of cultivation. But in other places like Daltonganj, Umaria and Pakur the annual loss brought about insidiously by this tiny buff-coloured moth must be very great indeed. In a godown in one of the above places, I found enormous swarms of the moth in every stage of development. The number of adult moths within it was so great that it was impossible to enter it without having to cover the face. The adult moth is found both in the stored lac, as well as the brood-lac on the trees. The moth lays its eggs on the resinous cells, preferably in the depressions between two cells. The young caterpillar on hatching enters the cell, and goes in directly for the dried and otherwise affected cells. But in doing so, it damages the healthy females within resinous cells, and is partly responsible for the subsequent meagre emergence of larvæ. It occurs along with *Eublemma amabilis* and considerably damages the crop on the trees, as well as in the godown. The

fullfed caterpillars, prior to pupation, spin narrow, silken galleries which are freely interspersed with pellets of excreta and bits of resin from the lac cells. I have met this moth in its various stages of development in *ber*, *palas*, *kusum*, *ghunt-ber* and *Ficus* stick-lac but have not found it in *jalla* stick-lac (*Shorea talura*) from Mysore. There its place is probably taken up by *Pyroderces falcatella* (Plate XXVII, fig. c). The effect of the presence of these caterpillars is that the stick-lac does not wash out well and if the stuff has become exposed to the heat, either directly or indirectly, it becomes blocky and as such deteriorates in value. It is always better to insist on the purchase of seed-lac only. This innovation is fraught with great possibilities for future good. If the manufacturer will persist in buying seed-lac the cultivator will cut his lac after the emergence of larvæ has taken place. This will yield more brood-lac wherewith the cultivation will expand. If, however, the cultivator will be advised to wash the stick-lac immediately after collection, the ravages of the predators such as *Eublemma amabilis* and *Holcocera pulverea* would be reduced considerably. If he will spread the red colouring matter—technically known as the lac-dye—over his field and incorporate it with the soil the land would benefit to some extent. The manufacturer's bill for washing charges will be reduced considerably and he will be rid of the foul smelling lac-dye which is a nuisance and a source of danger to public health, especially in the vicinity of the factories. If, however, it is not found practicable to change the habits of the cultivators, it is advisable to fumigate the stuff either with carbon bisulphide or hydrocyanic Acid (HCN) under proper supervision (Appendix C, figs. 13, 14).

The effect of fumigating the stick-lac immediately after scraping it will be apparent from the following experiment conducted from brood-lac sticks obtained from Mathurapur Zemindari in Bengal where cultivation of lac on *ber* forms a part of the yearly zemindari operations. Two sets of 50 brood-lac sticks, each stick being 9 inches to 11 inches long, were put in four parasite-breeding cages of a special design. As soon as emergence was over, one set was fumigated with carbon bisulphide and the other remained unfumigated.

NOT FUMIGATED.

Cage A, 25 brood-lac sticks after emergence of larvæ, put in on 21st November 1919. From 29th November 1919 until 23rd August 1920—

Holcocera	588
Eublemma	124
Chalcididæ	349
TOTAL	1,059

Cage B, 25 brood-lac sticks after emergence of larvæ, put in on 21st November 1919. From 29th November 1919 until 23rd August 1920—

Holcocera pulverea	100
Eublemma amabilis	10
Chalcididæ	176
TOTAL	286

(In this cage, ants entered on the 16th April 1920 and retarded the full emergence of predators.)

FUMIGATED WITH CS_2.

Cage C, 25 brood-lac sticks after emergence of larvæ, fumigated with CS_2 on 21st November 1919.

From 20th November 1919 until 23rd August 1920. No moth or *Chalcid* emerged.

Cage D, 25 brood-lac sticks after emergence of larvæ, fumigated with CS_2 on 21st November 1919.

From 29th November 1919 until 23rd August. No moth or *Chalcid* emerged.

From the above it will be seen that from 50 brood-lac sticks a total number of 1,345 predators and parasites emerged, whilst from the fumigated material not a single predator or parasite was found to have emerged. As is the system at present, the *Beparis* and *Arahtiyas'* godowns are generally present in the lac-growing tracts, these obnoxious insects ultimately make their way to the crop on the trees and in course of time reduce it considerably. Those who have worked at this problem for some time know that in some years the number of parasites and predators is quite abnormal. The factors which govern the phenomenon are not well understood at present. But from what is shown above it is clear that these contribute no less to the poorness of the crop which is at times erroneously ascribed to other factors. If is therefore advisable either to wash the scraped material immediately after scraping it from the branches or to fumigate it and then store it in bags in godowns which should frequently be cleaned and fumigated with sulphur (Appendix C, figs. 13 and 14).

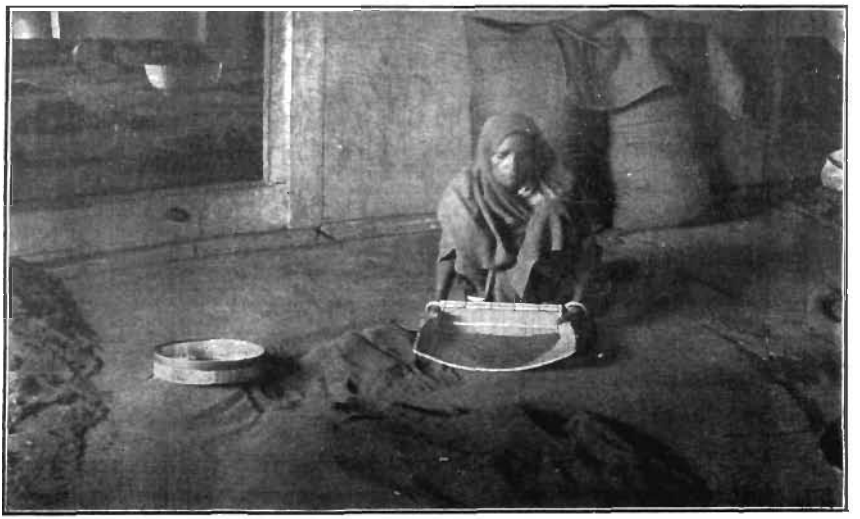
Washing lac.

After scraping, the lac should be thoroughly dried in the shade and sold to the nearest shellac factory or the local agents of these factories. If there be no agent in the neghbourhood or there be insuperable difficulties in disposing of the produce, it should be ground with an ordinary hand-mill (Plate XIX, A) and soaked in water for 24 hours. If the quantity is not large it can easily be rubbed with the hands in a stone vat or *nand* (an earthen vessel with a wide mouth and a thick bottom) until the colouring matter—commercially known as the lac-dye—is separated. More water is added and the stuff strained through a piece of cloth. The colouring matter is allowed to accumulate in a vessel

A. Grinding stick-lac in a hand mill. (Original.)

B. Sifting ground stick-lac. (Original.)

A. Washing lac. (Original.)



B. Sifting seed-lac from *melamma*. (Original.)

and the stuff again put back into the vat and briskly rubbed. More water is then added and the washed material again strained. This is continued until no more colouring matter comes out. A little washing soda (monohydrated sodium carbonate) is then lightly sprinkled over the washed product at the rate of 4 chhitaks (8 oz.) to a maund (40 seers or 80 lb.) and the whole again rubbed briskly and more water added. By doing so the last trace of the colouring matter is taken out and the resultant washed material is of a beautiful, pale orange colour—which is the seed-lac or *dal* of commerce. If an excess of washing soda is added it takes away the wax adhering to the particles of the lac which when warmed becomes very brittle.)

Samples of treated seed-lac were sent to Messrs. Parsons & Keith, London, and their report on them is quoted below *in extenso* :—

1. *Kusum* . . Untreated, 45*s.* per cwt.—Rs. 24-11-3 per maund (82 lb). Remarks—Good quality, only a limited sale.
2. *Kusum* . . Treated, 85*s.* per cwt.—Rs. 46-10-9 per maund (82 lb). Remarks—Very fine, bold, clean seed-lac. We have not seen any as good as this before here. There would be a good ready sale if the price could compete with fine orange shellac and Karachi seed-lac. In Karachi there is a fairly large business done, but this quality would be preferred by buyers.
3. *Palas* . . Untreated, 35*s.* per cwt.—Rs. 19-3-6 per maund (82 lb). Remarks—Small stick-lac, not very saleable.
4. *Palas* . . Treated, 75*s.* per cwt. Rs. 41-2-11 per maund (82 lb). *Remarks—Good quality, pale seed-lac, rather small.* The same remarks apply to this.

They further said : "Before speaking with absolute certainty, we shall have to test the samples marked 'treated' to see that they are saleable, but judged by their appearance buyers seem to be taken with the treated samples, especially the *kusum*. This class of lac has only been shipped here in small quantities so far from Mirzapur and it occasionally fetches a high price for special purposes. To be sold in large quantities it would have to compete with shellac and the price would vary with the price of shellac. We believe the treated would meet with a ready market and would fetch, roughly speaking, double the price of the untreated. Based on the present price of shellac, we think you could safely reckon to sell the *kusum* treated in quantity at 85*s.* per cwt. and the *palas* treated at 75*s.* per cwt. We should recommend a trial shipment of 20 to 25 bags of each quality."

From available information, it appears that such a special brand of seed-lac is required for special purposes only, as for lacquer work and in casings to cable.

In factories, the washing is done in large stone vats placed in a row on a *pucca* or cemented platform. (Plate XX, A.) Ground and sifted

stick-lac is put into these vats and soaked in water for 18 to 24 hours. The professional washers then stand upright in the vats and gyrate briskly, taking for their support bamboo poles fixed by their sides. When the material is sufficiently washed the plugs at the bottom of the vats are opened and the washed stuff run out on to graduated sieves placed below the plugs. The colouring matter runs out and accumulates in a large tank especially built for the purpose. The half-washed resin is again put back into the vats and the washing continued until no more colouring matter comes out. The seed-lac is then dried in the sun and graded into granular seed-lac and dust—commercially known as *gund*. The lac-dye in the tank is then precipitated either with quick-lime, lime-water or oxide of tin.

A professional washer can wash from one maund to a maund and a half at rates varying from annas eight to annas twelve a maund. But a cultivator—who is not accustomed to washing—cannot be expected to wash more than 15 seers per day.

A maund (40 seers or 80 lb.) of *ber* stick-lac ground and washed with water will yield 18½ seers of clean seed-lac with 30 to 32 gallons (150 to 160 seers) of workable lac-dye. A maund of *ber* stick-lac experimentally crushed and washed gave:—

Before washing.	Srs.	ch.	*After washing.*	Srs.	ch.
Granular . . .	25	4	Granular . . .	18	8
Small granular and dust .	12	12	Small granular and dust .	10	4
Refuse, sticks, thorns, etc.	2	0	Lac-dye, etc. . . .	11	4
TOTAL .	40	0	TOTAL .	40	0

The quantity of water required to wash the above was 140 gallons (17½ mds. or as much as could be contained in 35 kerosene tins).

Uses of the lac-dye.

By washing stick-lac with water two things are obtained:—

I. Pure resin commercially known as seed-lac and used for the manufacture of shellac.

II. Lac-dye.

Before the introduction of aniline colours the latter product was extensively used for colouring wool, leather and silk and generally represented the manufacturer's margin of profit.

But now it has to be thrown away and better prices are paid for a material which contains a smaller quantity of colouring matter in it. The dye can still be used for the manufacture of *altas* or balls of cotton-wool soaked in concentrated lac-dye and used by Hindu women for

colouring the soles of their feet. Besides, it contains some nitrogen and as such could be used advantageously as manure for the rice fields. The dye should be extracted from stick-lac as soon as it has been scraped from the branches, as it has been found that by long storage the manurial ingredients of the lac-dye diminish. Large quantities of the dye in the form of cakes are now available, and if these could be used for the extraction of carmines, the manufacturers would gain something out of the by-product. A portion of nitrogen is present in the form of ammonia, while the balance is contained as an albuminous substance. The following analysis by the Imperial Agricultural Chemist, Pusa, of a Bengal sample exemplifies this:—

Specific gravity	1·003
Nitrogen	0·014 per cent.
Phosphoric acid	0·004 ,,
Potash	0·008 ,,

After washing, the lac-dye can be spread over fields and worked into the soil with an ordinary plough. It can also be used for dyeing eri-silk. The cloth, if previously mordanted with alum, takes a beautiful red colour which is not affected by human perspiration. For dyeing eri-silk take 3½ chhitaks (7 oz.) of stick-lac free from dirt, pieces of sticks and other impurities, grind it fine and boil it in a seer (2 lb.) of clean, soft water until a deep red liquid is obtained. Then take it off the fire, cool, strain and keep aside; the silk thread to be dyed should be mordanted with a saturated solution of alum in cold water and spread out to dry; the latter is then to be boiled in the former until it assumes a deep red colour; when cool it is to be rinsed with cold water and spread out to dry in the shade. If desired, the colour can be softened by acidulating the water with a trace of fresh lemon juice.

Manufacture of shellac.

As soon as branches bearing lac have been cut from the trees, they are either put on to other trees already pruned for the purpose so as to infect them with the lac larvæ or they are put out in the sun to dry. A week or so afterwards, lac from such branches is either scraped off by knives (Plate XVIII, A) or by being broken under a *dhankali* or chunam-grinding mill. The cultivator takes this stuff for sale to the local markets, and it is there purchased by *Beparis* on their own account or for the *Arahtiyas* residing in important lac-growing centres. The *Bepari* purchases the lac on the basis of *beuli, i.e.*, clean, dry stick-lac without any adulteration. The manufacturer, after purchase, grinds the stick-lac in hand stone-mills (Plate XIX, A). The crushed stick-lac is

then winnowed and sticks and other foreign matter are picked out by hand (Plate XIX, B). The sifted material is then soaked in stone vats for 24 hours. It is then worked out by men who stand upright in the vats and turn sideways. Water is then added and the material is then strained through cloth bags (Plate XX, A). This is repeated until no colouring matter, technically known as the lac-dye, comes out of the stuff. The washed product, technically known as seed-lac, is then spread out in the sun to dry in a thin layer on a *pucca* platform within the factory. When thoroughly dry, it is again sifted and graded into (*Plate XX, B*) :—

I. Large granular .	. Used exclusively for the manufacture of superior grades of shellac such as Standard I and superfine.
II. Small granular .	. Generally (mixed with I and) utilized for the manufacture of T. N. shellac.
III. Dust . .	. Known as *nolamma*, which is used for the manufacture of low grade shellac and is generally mixed with No. II. It is also used for making toys and bangles locally. (Fig. 28).

Fig. 28 Sifting *nolamma*. (Original).

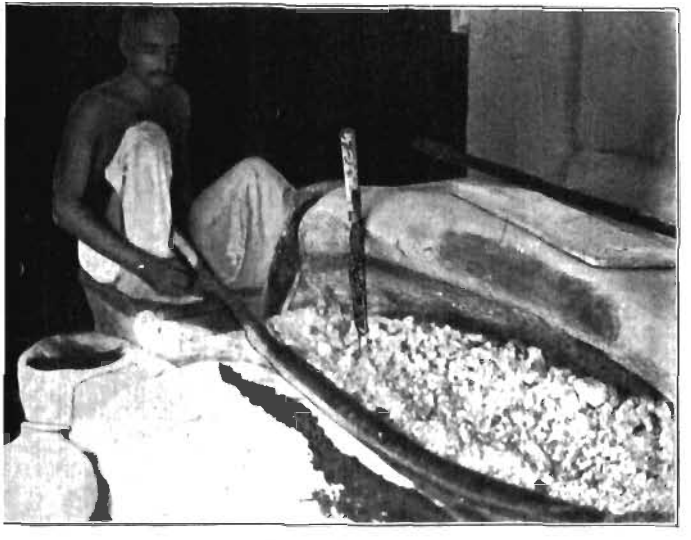
To the granular seed-lac is then added 2 to 3 per cent. of yellow orpiment or arsenic to impart colour, and 4 to 5 per cent. of pine resin to lower the melting point, especially when the stick-lac was old or stored for a considerably long time. If, however, a special brand of shellac is to be manufactured, such as that used for coating chocolates and other confectionary, arsenic is totally avoided. If shellac is to be used for the manufacture of high grade varnishes, or electrical composition material, no resin is mixed. But these are some of the special uses. Ordinarily the trade allowance is $1\frac{1}{2}$ to 2 per cent. of resin, though a stuff with the above limit is not generally met with. At times, when the prices of shellac are high, the percentage of adulteration with resin is very high, and in the past efforts were made to find out an easy process whereby the adulteration could be readily and definitely checked and this was known as the iodine-test of shellac. Recently the important shellac manufacturers have formed associations of their own, such as the Chapra Vyapar Vardhini Sabha of Mirzapur, United Provinces, to put down the nefarious practice of adulterations. Such a society limits the admixture of resin, and if a manufacturer persists in putting up for sale a resinous material, heavy refraction is charged as a deterrent. After mixing, the mixture is filled into long, narrow double cloth bags, 10 to 12 yards long and 2 to 3 inches in diameter. The bag is generally made of Cawnpore drill No. 2 selling now at 10 annas a yard, and generally contains 20 seers of mixed seed-lac. It is usually worked by two men and a boy or woman. One end of the bag is held by the *karigar* who sits at one end of the *bhatta* (oval oven) in which charcoal is kept burning and the other is turned round on a *pherki* by a boy or a girl. The twist given to the *pherki* by the boy is opposite to that given by the *karigar*. At one time or another about five feet length of the bag is in front of the *bhatta*, and in consequence the mixture of *chauri*—technically known as seed-lac—arsenic and resin gets cooked up. The melted resin oozes out of the bag and drops on the stone slab in front of the *bhatta*. The *karigar* keeps the bag slowly turning round and at the same time watches the melted resin. That which sticks to the bag he scrapes out with a *chadna* and mixes it with that which has dropped on the stone slab. He then briskly mixes up the two together either on the bag itself in front of the fire or on the stone slab below. When the mass has become thoroughly incorporated and has assumed the particular consistency, the *karigar* hands over the melted mass of resin to his assistant, the *bhilwaya*, who promptly takes hold of it and lays it on the porcelain cylinder containing hot water. With a double sheaf of palm leaves, locally known as *nera*, he spreads it flat. If, however, any excess is left over it is handed over to the *karigar* to be worked up again (Plate

XXI, A). The *bhilwaya* then takes up the thick piece of hot resin in front of the oven and when it has regained the proper amount of heat by exposure, he moves away and holding the sheet between his toes, hands and teeth, quickly stretches it into a thin, long sheet (Plate XXI, B), and keeps it flat on the ground. When a sufficient number of sheets have thus been got ready, they are examined for any defects. If there are hard knots or unsightly air-bubbles, these are punched out along with the thick borders of the sheets. These are again ground fine and filled in the bags. The whole process is expeditiously and smartly done by men who mostly come from Mirzapur in the United Provinces. With the opening of the shellac factories in most of the lac-growing tracts such as Ranchi, Jhalda, Purulia, Balarampur, Daltonganj, Pakur and Calcutta, a number of local men have also learnt to make shellac but the productions fall much inferior to those manufactured by Mirzapur *karigars*. A worker with two assistants is capable of turning out a maund of shellac per day, for which he charges Rs. 2-12. The average cost of production of a maund of shellac is Rs. 15 though this sum varies considerably from place to place. An average of 20 seers of shellac is obtained from a maund of good, clean *beuli* lac.

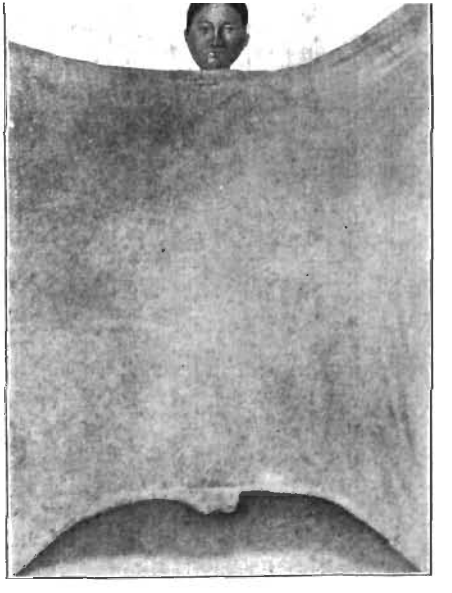
In large factories where large stocks accumulate, the sheets of shellac after examination are broken up into small pieces. These are then spread out in large well ventilated rooms to aërate. At times, and especially during the hot season, when the maximum temperature outside ranges between 110° and 115° fans are worked in such rooms to keep the temperature down (Plate XXII, B). When thoroughly dry, it is filled in gunny bags and sent down to Calcutta (Plate XXIII, B) where it is refilled in chests by the shippers who export it. Each chest contains two maunds of shellac and bears distinctive trade marks.

During the process of manufacture of shellac, the *karigar* relieves the bag of its extra weight so as to prevent it from sagging unduly before the fire in the *bhatta* by punching out the hot *kiri* (Plate XXII, A) with *kiri-kudna*. This falls as a blackish semi-solid mass on the stone slabs in front of the *bhatta*. It is then worked up into round, flat slabs known as *kiri*-cakes which are locally used for making bangles and toys. The twisted ends of bags, known as *dandis*, are boiled down in huge copper cauldrons, which simmer over a specially designed *bhatti*, in which refuse from lac washings, known as *bhusi*, is burnt. With the addition of monohydrated sodium carbonate the refuse matter coagulates and floats over the surface of the cauldrons in the form of a brownish flaky mass (Plate XXIII, A).* It is then laddled out and, whilst still hot, is

* *The figures on Plates XIX—XXIV have been inserted through the courtesy of* Lala Mahadeo Prasad, Proprietor of the Firm of Mahadeo Prasad Kashi Prasad, Shellac Manufacturers, Mirzapur, U. P.



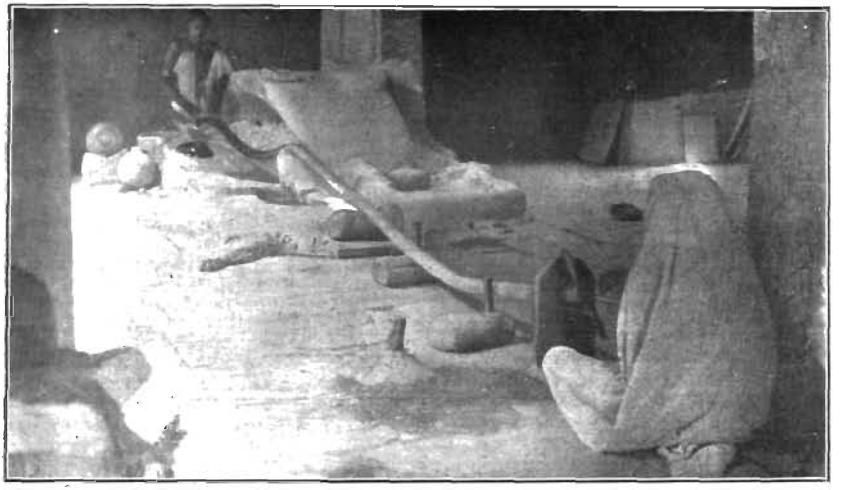
A. Preparation of shellac—before the *bhatta*. (Original.)



B. Drawing out melted shellac into a sheet. (Original.)

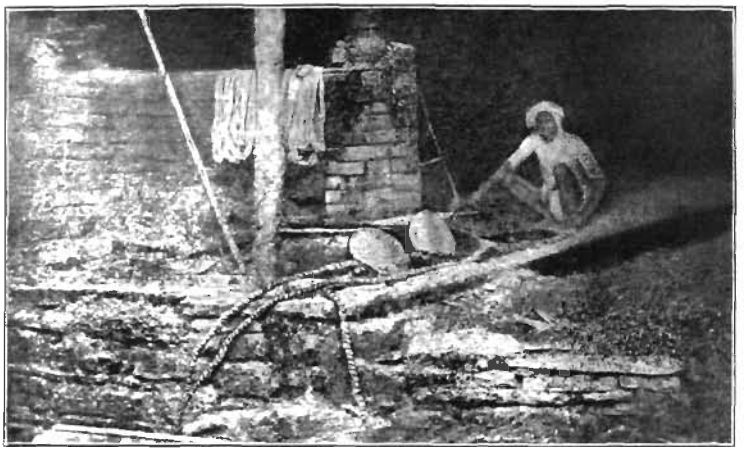
PLATE XXI

PLATE XXII.

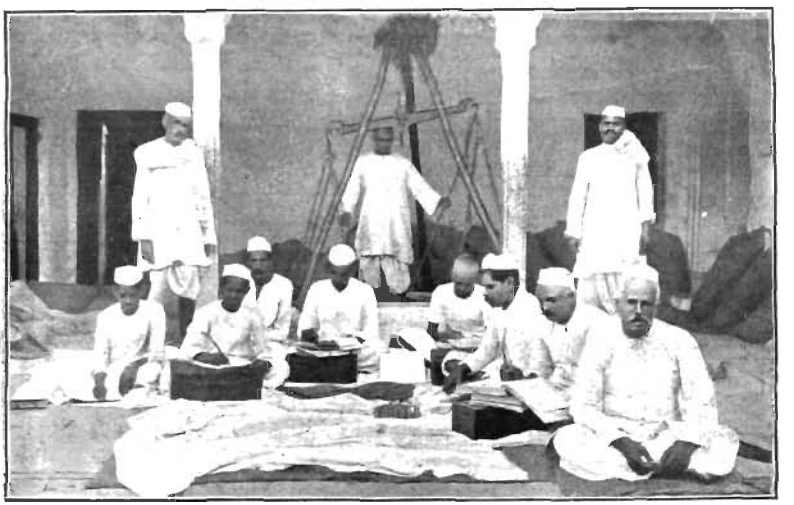


A. Punching out *kiri* from the cloth-bag. (Original.)

B. Aërating shellac during the hot weather. (Original.)



A. Boiling down. *pass via.* (Original.)



B. Bags of shellac ready for export. (Original.)

compressed into circular flat cakes known as *Passewa* which is reground and worked up in the bags again.

Uses of shellac.

The present uses of shellac locally are :—

(1) For making bangles, toys and lacquer work. The woodwork of Benares, Jaipur and Chennapatna in the Mysore State are exquisite pieces of delicate workmanship.
(2) For making milk churns, shuttles and bobbins.
(3) For making grinding stones.
(4) For fixing hafts to swords.
(5) For making bracelets and sealing-wax.
(6) By goldsmiths for filling ornaments.
(7) For the manufacture of micanite, with alternate layers of shellac and mica dust.
(8) For the manufacture of gramophone records.

Its foreign uses are :—

(1) For the manufacture of gramophone records and pianola rolls.
(2) For the manufacture of varnishes and polishes. High grade shellac is especially used for varnish for aeroplanes.
(3) For the manufacture of sealing-wax and lithographic ink. Bleached shellac is now much used for the manufacture of variegated, perfumed sealing-wax sticks.
(4) It is used instead of gelatine for stiffening hats.
(5) It is used as a substitute for leather ; canvas and shellac being used now-a-days for the manufacture of shoe tips.
(6) It is used for Semaphore signalling and as a filling material for shrapnels.
(7) It is used by manufacturers for silvering the backs of mirrors.
(8) For plastic or composition material.
(9) As an insulating material in electrical works.
(10) In confectionary, as a cover to chocolates, etc. For this, shellac, without arsenic, is generally used.
(11) For painting the bottom of ships to prevent the corrosive action of the water on steel plates.
(12) For encasing cable wires.

When shellac is bleached, it is put to a number of uses. Formerly chlorine was mostly used for bleaching shellac, but now better results have been obtained by using sodium hypochlorite. The uses of bleached shellac are :—

(1) Imitation ivory, especially for the manufacture of billiard balls, backs of brushes, combs, tooth-brushes, poker chips, etc.

(2) All white insulated goods.

(3) For the manufacture of paper and leather varnishes.

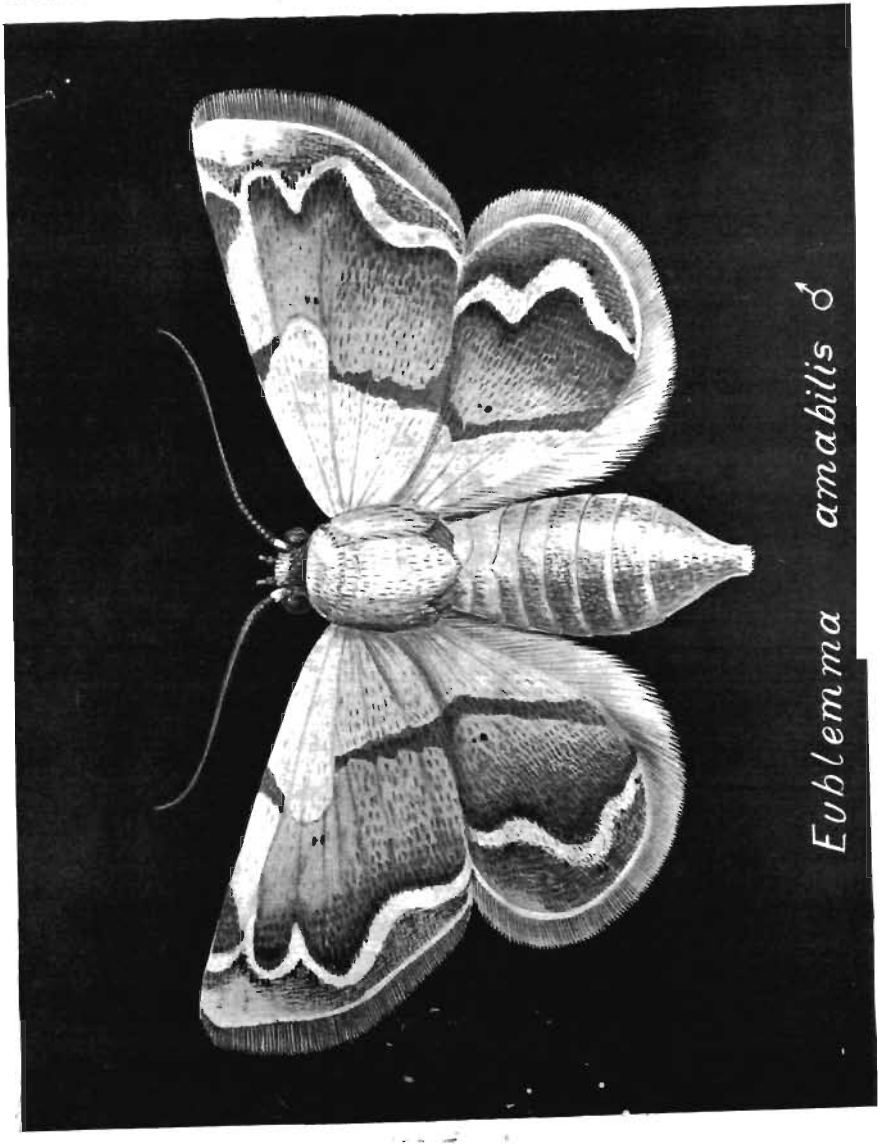
Bleached shellac, if exposed to the action of the sun and the air, changes colour and deteriorates fast. It is, therefore, stored in water in large drums which are then exported.

When shellac is refined for special purposes, a wax is obtained which is used for casting medallions and coins. It is always used for sealing valuable documents and is one of the hardest waxes known. It is also used as an ingredient in boot and shoe polishes. When freed of the wax, shellac becomes especially adapted for the manufacture of plastic material so much now utilized for the making of soft felt hats.

Adulteration of shellac.

In seasons when the crop is poor the prices of shellac occasionally go high and this leads to the manufacture of various grades of adulterated shellac. So much skill and tact is brought to bear upon the question that, had the same energy been directed in proper direction, the present cry raised by the foreign consumers against the Indian product would not have been heard of. A number of unscrupulous manufacturers use various ingredients to adulterate shellac; of these pine rosin is the most important. In some years very high adulterations of resin have been detected and this detracts from the special uses to which shellac is put. Any adulteration over 3 per cent. is sure to facilitate the introduction of the synthetic product in the market. As at present, the synthetic product cannot hold its own against the special qualities of shellac, first and foremost of which is that it prevents oxidation of the surface over which it is applied as a thin film, and secondly that it does not crack so easily when exposed to the atmosphere. The admixture of other foreign substances with pure resin prevents shellac from being utilized for special purposes for which it is eminently suited. Two decades back it was not very easy to detect the adulterants with any amount of certainty, but now methods have been perfected by which they may be detected. There are special uses to which shellac is put now-a-days, and it is advisable that manufacturers should clearly state that the stuff does not contain any trace of orpiment and that it does not contain more than 2 to 3 per cent. of pine rosin. Of course, there are certain uses where resinous shellac is required, and in such cases it would be better to specify clearly the percentage of rosin in the material offered for sale. The petty manufacturer in the outlying places does not feel the gravity of the situation, and does not probably feel the immensity of mischief that he is doing to the trade. The foreign consumer is very sensitive and wants to have a standard material of uniform consistency

PLATE XXV.



and composition, and I think, it behoves all who are interested in the trade to see that malpractices are put down and that sustained efforts are made to produce only standard material for foreign consumption. If this is done, it will be seen that the consumption of shellac would increase and that better prices would be obtained. The stigma that attaches to the Indian product would be removed and it would once more establish its reputation for purity and uniform consistency.

Enemies of lac.

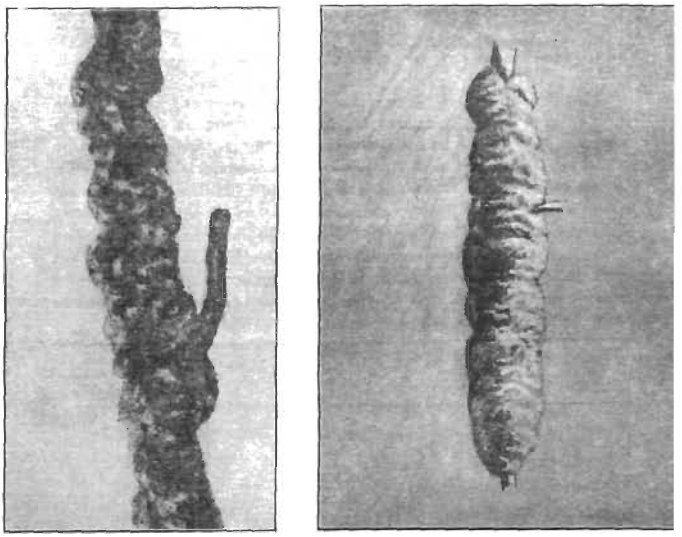
Every one who is engaged in the cultivation or manufacture of shellac knows that it is seldom that a normal crop of lac is obtained. It is susceptible to the influence of many factors of which the following are the most important :—

I. Insect Pests :
   (*a*) Predators.
   (*b*) Parasites.
II. Frost, forest fires and hot winds.
III. Other factors such as men, monkeys, squirrel and cattle browsing against inoculated trees.

I (a) Predators. Of these (1) *Eublemma amabilis*, Moore, (Plate XXV) does immense damage to lac on trees as well as in stores. In some localities it is so bad that the majority of the crop is spoiled by it and in such localities it is not possible to introduce lac cultivation. In fact the predator is present wherever lac cultivation is done to an appreciable extent. From examinations made of broodlac sticks from different localities it has been found that the district of Hoshangabad in the Central Provinces is comparatively free from the predator than other lac-growing areas. In Burma it seems to be especially present in large numbers. In Assam a ten-inch stick covered with lac had as many as 480 exit holes of the predator.

Locality	Length of sticks	Number of exit holes of the predator on lac on sticks
Bangalore	3″	15
Hashimbat (Assam)	8′	37
Palasbari (Assam)	25″	109
Hyderabad (Deccan)	88″	356
Daltonganj	20′	72
	37′ 8″	589, *i.e.*, 1·3 holes per inch.

In examinations made of *Kartiki* and *Baisakhi* broodlac sticks it was found that the number of egg, larvæ and pupæ of the predator were present more in the former than in the latter, and in examinations made of the broodlac left over on the trees for propagation for the *Kartiki* crop it was found that a fairly large number of moths continued to breed in these. The moth is crepuscular in habits and as such is not much seen in plantations. It lays small, flattened eggs, depressed in the centre on the resinous incrustations. The eggs when freshly laid are pale yellow in colour. The egg-shell is finely tassellated and in the course of a few days it turns deep brown. The larva comes out by biting a small hole at the side and enters the resinous incrustation immediately. It goes on tunnelling, killing and devouring a large number of females. The maximum number of eggs laid by a female was 445, whilst the

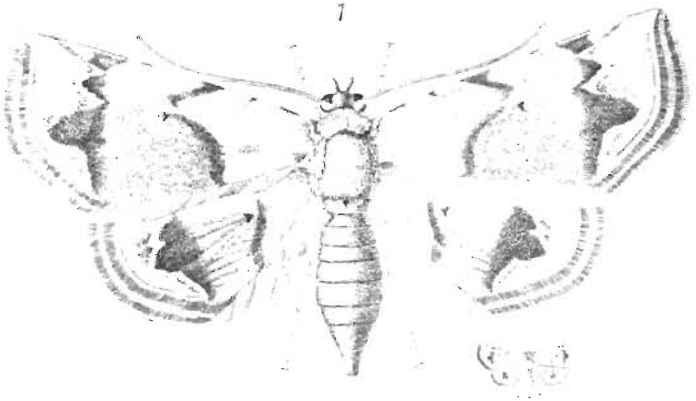


a *b*

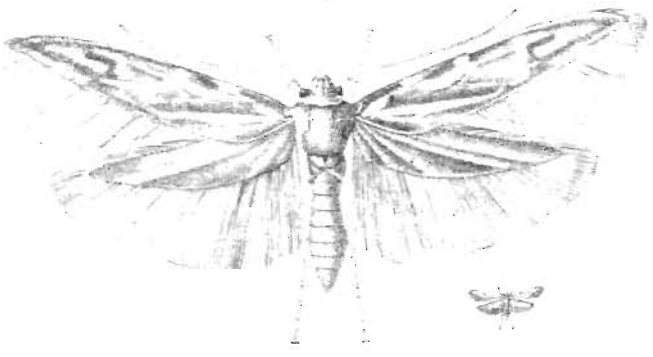
FIG. 29. Aberrant pupal chambers of *Eublemma amabilis* in lac.
(*a*) *Shorea talura* lac, Bangalore. (*b*) *Kusum* broodlac, Kauker, C. P.
(Original.)

PLATE XXVI.

1



2



1. *Eublemma amabilis.*

2. *Holcocera pulverea.* (Original.)

maximum number of eggs in the ovary was 679. The eggs hatch from 6-9 days from June to October and 20-32 days from November to February. A female begins to lay eggs from 24 hours to 13 days after fertilization and continues to do so for 1 to 6 days (Plate XXVI, Fig. 1). The larva when full fed spins a silken cocoon in the gallery within the resinous incrustations and pupates. At times it makes galleries which protrude from the resinous incrustations. Such galleries

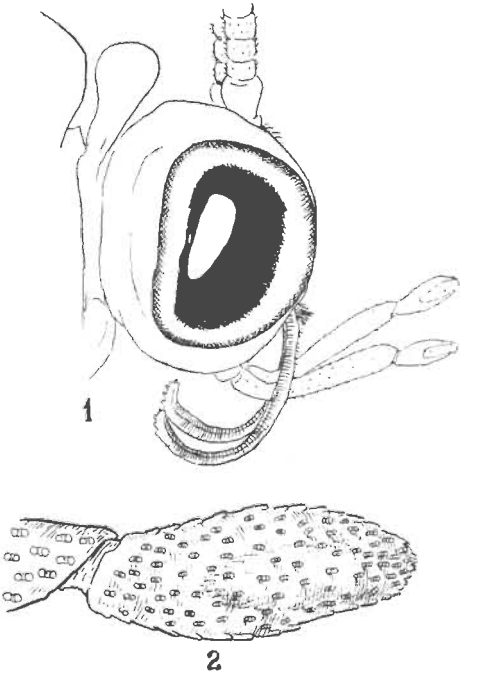


FIG. 30. *Eublemma amabilis.*
1. Proboscis and labial palpi.- lateral view.
2. Apex of labial palp, much enlarged.
(Original.)

are prominent and are readily seen. The adult moth emerges by forcing out the cap of the gallery (Fig. 29). It then remains resting for some time. It is then chalky white in colour and very sluggish in its movements. It rests with its wings spread out and the palpi pointing forwards (Fig. 30). It is presumed that parthenogenesis occurs in this group and that the larvæ are cannabalistic in habit, especially when in confinement. The moth has been recorded from :—

Bengal	Mathurapur (Malda), Dhulian, Protapganj, Nimtita, Rajgan, Berhampur, Khatra (Bankura). Rampur-hat.
Bihar and Orissa . . .	Pakur, Haranpur, Chhatra, Manari, Dumka, Ranchi, Jhalda, Purulia, Manbazar, Balrampur, Thulin, Chybassa, Kundri (Daltonganj), Hazaribagh, Sambhalpur, Sagrampur (Bhagalpur).
United Provinces . . .	Chakia (Benares State). Jhansi, Kheri, Dehra-Dun, Pathri (near Hardwar).
Central Provinces . . .	Damoh, Kota, Raigarh, Raipur, Baurod (Dhamtari). Kanker, Betul, Katni, Damoh, Bhandara. Hoshangabad, Yeotmal, Jabbalpur, Melghat, (Berar).
Bombay Presidency . .	Sind (Mirpur-Khas, Dhoro Naro, Digri, Jamesabad)
South India	Warangal, Nirmal (Hyderabad-Deccan), Jeypore (Vizagapatam), Bangalore, Arramboly (Travancore), Banganpalle.
Assam	Hobima hat, Palasbari, Baitulanshu, Antring, Umran, Barbala Estate, Sonarpur, Barpani Estate.
Punjab	Hoshiarpur, Una Tahsil.
Indian States	Umaria (Rewa), Mayurbhanj, Panna, Maihar, Gwalior ; Billawar and Udhampur (Kashmir).

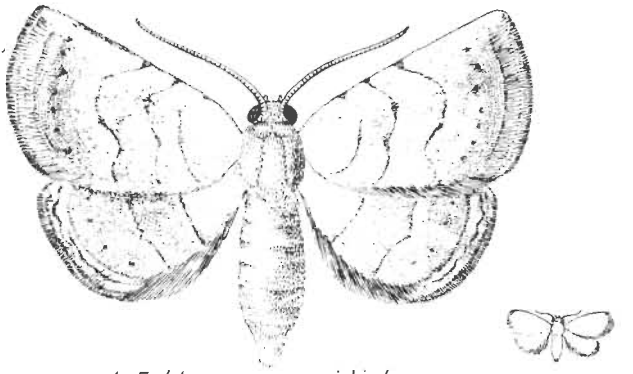
It has also been reported by Mons. L. Duport as attacking lac in Tonkin (Indo-China)*

Eggs laid	7-x	2-x	2-x	2-x
Eggs hatched	13-x	3-x	7-x	9-x
Larva pupated	11-ii	5-ii	4-ii	11-x
Adult emerged	18-ii			14-ii
	to	24-ii	28-ii	28-ii
	25-ii			
	136—142	146	150	160 days.

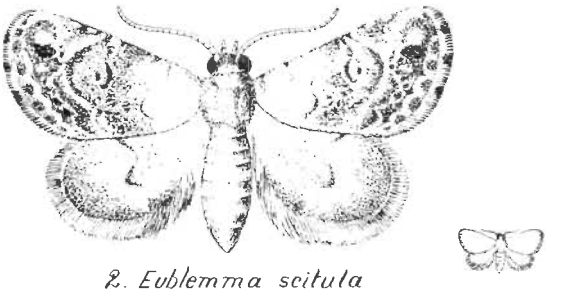
Bracon tachardiæ Cam. (Plate XXVIII) parasitises the larvæ to a considerable extent and is present in most of the lac-growing areas where *Eublemma amabilis* is found. At times the grubs of the parasite are found on the lac females within resinous tests. In fact it is the primary parasite of the predator *Eublemma amabilis*.

* Duport, L. L.—Insecte à stick-lac. Bull. Ecomm. De L. Indochine, No. 112, 1915, pp. 187—188.

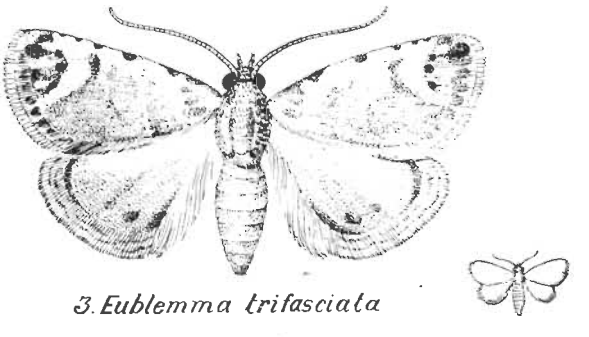
PLATE XXIV.



1 Eublemma coccidiphaga



2. Eublemma scitula



3. Eublemma trifasciata

There are three other species of *Eublemma* (Plate XXIV.)

1. *Eublemma coccidiphaga*, Hamp.	
Pusa	Feeding on a Coccidæ Nowarpur, Assam.
2. *Eublemma trifasciata*, Moore.	
Pusa	Feeding on *Pseudococcus corymbatus*, Gr. and *Phenacoccus hirsutus*, Gr.
Mandalay	Feeding on *Cerococcus hibisci*.
Muzafferpur.	
Bassein (Bombay).	
3. *Eublemma (cretacea) scitula*, Rambr. Pusa . .	Feeding on a Coccidæ. Feeding on *Ceroplastes floridensis*.
Calcutta	Feeding on a Coccidæ.
Coimbatore.	

Of these *Eublemma scitula*, has been recorded from lac in South India, but hitherto it has not been found to attack lac in Northern India where it is mostly found feeding on *Ceroplastes floridensis* and *Pulvinaria* spp.

(2) *Holcocera pulverea*, Meyr.

Blastobasis pulverea, Meyr. *Bomb. Jour.*, Vol. XVIII, p. 131, 1907.

**Hypatima pulverea*, Meyr. loc. cit.

Hypatima pulverea, Meyr. Lefroy, *Ind. Ins. Life*, p. 536, 1909.

Hypatima pulverea, Meyr. Misra, *Bull. No. 28, Agri. Res. Inst.*, Pusa.

Holcocera pulverea. Fletcher, p. 24, 1912; *Mem. Dept. Agri. Ind.*, Vol. VI, Nos. 1—9, pp. 130—131, Nov. 1920.

The caterpillars were thought hitherto to be more or less scavengers feeding on dry matter within the cells. But now it has been ascertained definitely that they, like *E. amabilis*, feed on the lac-insects, especially on the females in process of growth on the branches of trees. They are present in large numbers in the stored stick-lac in godowns, as well as the lac that is left over on the trees. In fact, in some localities the number of these caterpillars is far in excess of *E. amabilis* caterpillars. In an examination of stick-lac in store from Mathurapur (Bengal), Ranchi, Hyderabad (Deccan), Daltonganj and Bangalore, it was found that twenty-eight pounds contained as many as 1,104 larvæ, pupæ, and adult moths or on an average 38 *Holcocera pulverea* to every pound of stored material. Larvæ, pupæ and adult moths are also present on the lac that is left over on the trees. In 475 feet of stick length, as many as 1,349 (Eggs, larvæ, pupæ, adults) *Holcocera pulverea* (Plate XXVI, fig. 2) were detected or an average of two *Holcocera* per inch of stick length.

* Mr. E. Meyrick wrote on the 21st September 1908, "*Hypatima pulverea* and *H. doleropa* pass into one another and represent one species, for which the name *H. pulverea* must be adopted."

It is on account of the abnormal presence of these, together with *Eublemma* and *Chalcididæ*, that, in some years when climatic conditions are favourable to their growth the crop suffers to a large extent. The moth lays tiny, white eggs in the cavities between incrustations, and the caterpillar on hatching bores into the resinous cells, much in the same way as the *Eublemma amabilis* caterpillar does. It takes 54 to 61 days to complete a life cycle in the beginning of the cold weather.

Eggs laid	9·ix	10·ix
Eggs hatched	14·ix	15·ix
Larvæ pupated	23·x	27·x
Adult emerged	2·xi	10·xi
	54 days	61 days

Under laboratory conditions, in a few cases, the caterpillars were observed to attack and devour *E. amabilis* pupæ, and it is possible they destroy a number of *E. amabilis* as they lie in the tunnels in lac incrustations on the trees.

The moth has been reported from :—

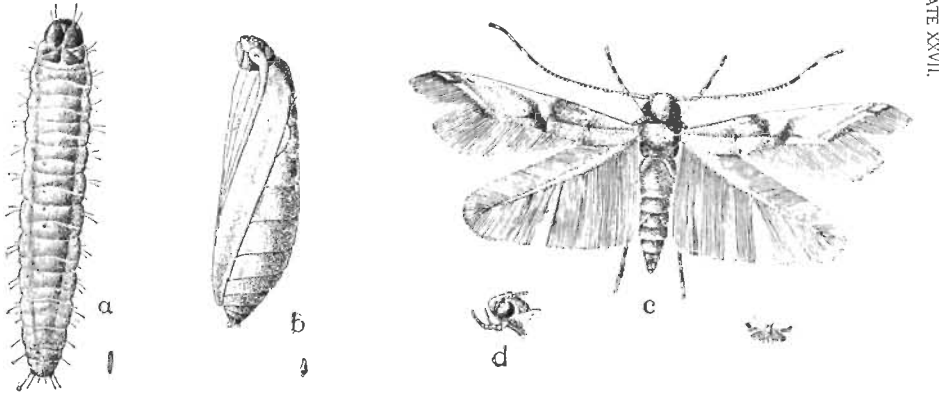
United Provinces	Kumaon.
Bengal	Mathurapur (Malda), Khatra (Bankura), Protapganj (Berhampur).
Assam	Khasi Hills; Shillong.
Bihar	Ranchi, Thulin, Jhalda, Purulia, Chybassa, Daltonganj, Dumka (Sonthal Parganas).
Central Provinces	Raipur, Damoh, Berars.
South India	Coimbatore.

It passes the winter in the larval and the pupal conditions. Hitherto no large parasitization of the species has been found, and it is because the caterpillar is cryptically coloured that it is extremely active and remains hidden within the resinous incrustations.

Next to *E. amabilis*, *Holcocera pulverea* damages the brood-lac on the trees as well as in stores. The dark fuscous, tiny moth is specially abundant in stores. In brood-lac on the trees it is found along with *E. amabilis*.

(3) *Pyroderces falcatella*.

Gracilaria ? falcatella, Stainton, *T. E. S.* (n. s.), V, 121, 1859.
Pyroderces spodochtha, Meyr., *Bombay Jour.* 607, 1905.
Anatrachyntis falcatella, Meyr., *Exotic Micro.*, I, p. 325, 1915.
Anatrachyntis falcatella, Fletcher, *Mem. Dept. Agri. India*, Vol. VI, Nos. 1—9, p. 99, Nov. 1920.
Anatrachyntis falcatella, Misra. *Proc. Fourth Entl. Meeting, Pusa*, 1921, pp. 229-451, Plate I.



Pyroderces falcatella, Stainton.

a, larva ; *b*, pupa ; *c*, moth, natural sizes and magnified ; *d*, side-view of head of moth (magnified).

The moth (Plate XXVII a, b, c, d) has hitherto been recorded from the following places :—

Pusa, 1913, 1914, 1916. From cotton, cotton buds, in cage containing *Dactylopius* sp., from *Eublemma* cage and on lac.
Calcutta.
Shillong, October 1916.
Golachettipalayam (Coimbatore District) on a rotten pomegranate.
Kandy (Ceylon). Larva in resinous masses of lac Coccid, *Tachardia albizziæ*.
Belgaum (Bombay). Cotton seed.
Myingyang (Burma). Cotton.
Shripur Farm (Bihar and Orissa). Cotton seeds.
Sonapur Tea Estate (Assam). On Lac.

The caterpillars occur in healthy brood-lac along with *Eublemma* caterpillars. They have mostly been found in brood-lac on *jalla* (*Shorea talura*) from Bangalore (Mysore State). In North India, the moth has been recorded mostly as a feeder on rubbish, etc., the only exception being in one instance at Pusa where it was recorded on lac. In the specimens of brood-lac on *Shorea talura* received from Bangalore, the caterpillars were fairly abundant and could be easily differentiated from *E. amabilis* caterpillars which were also present in the same sticks along with them. The methods of working of the two predaceous caterpillars are fairly distinct. *E. amabilis* caterpillars work from the side, as well as from the top side of the resinous cells enclosing lac females on the branches. *Pyroderces falcatella* caterpillars prefer to work mostly from the sides of the resinous cells. The caterpillar gnaws a hole at the side of the resinous cell and penetrates within. The passage of the *E. amabilis* caterpillars is filled with flat, oval discs of resin mixed with body juices of their victims. In some cases the resinous cells are completely hollow and are filled with dark crimson, flat, ovalish discs. The cocoon of the caterpillar consists of whitish silken threads glued together with deep crimson, flat, oval discs. Prior to pupation the *Eublemma* caterpillar makes a hole of exit, closes it with whitish silken threads and pupates immediately below it.

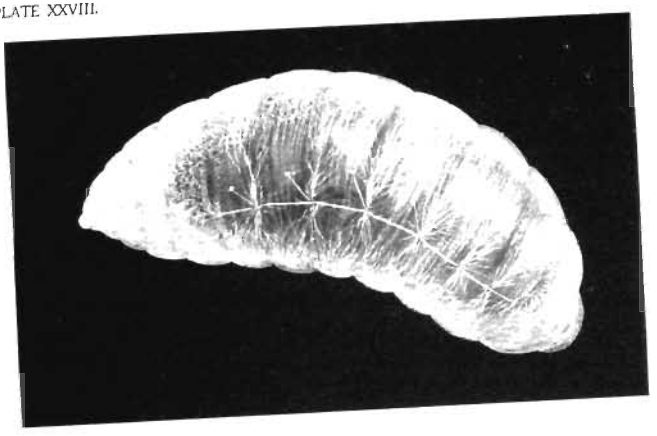
The *Pyroderces falcatella* caterpillars also make their way inside the resinous incrustation by gnawing bits of resin and then attacking the females. The bits of frass left by these caterpillars in the tunnels made by them are different from those of *Eublemma* caterpillars. In this case, the granules of resin are small and round. Both resinous and other granules consisting of chitin, dye and other visceral portions from the body of the lac females lie about the tunnels made by the caterpillars. So far as it has been possible to determine, the caterpillar in its attempts to reach the dead and dry female lac cells bites its way through

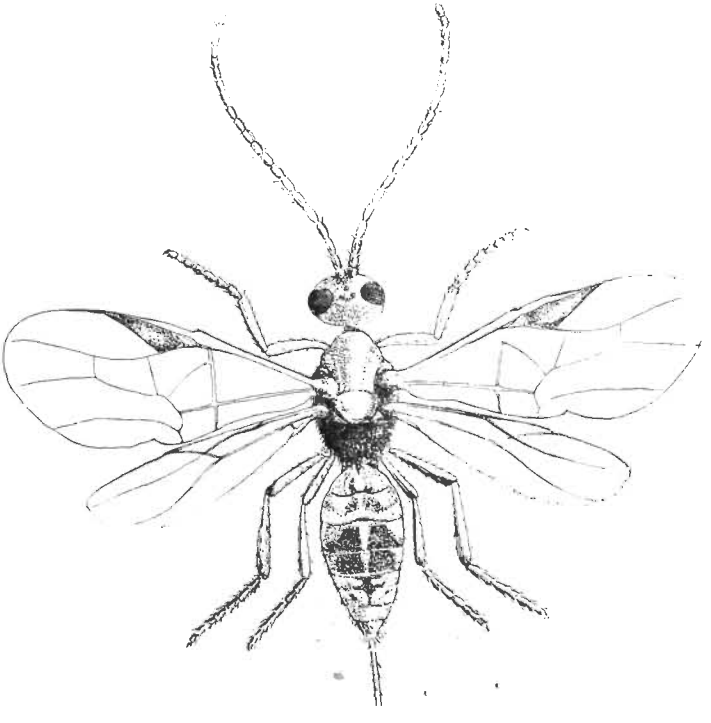
the living cells as well, and thereby causes their death. In one case, a caterpillar was seen to enter the resinous incrustation on a *Shorea talura* stick, from the side and within three days it has penetrated a length of 20 mm. when it began to pupate. It had thus killed off seven healthy lac females. The full-fed caterpillar is light crimson of much the same colour as the lac females. It is 5·75 mm. long, and a little over 1 mm. broad. It is light to bright pinkish in colour on account of the body juice of its victims which it has gorged. The head is jet black, with small whitish porrect hairs. The mandibles are jet black in keeping with the general colour of the head, and are very powerful. There is a shiny, black thoracic shield with an obsolete indentation in the middle. The general colour of the caterpillar is light pink with small white hairs on the body. There is a fine transparent longitudinal line from the first abdominal segment to the anal end through which the pulsation of the heart could be seen under high magnification. The caterpillar, when full-fed, spins a thin whitish cocoon. Prior to pupation it makes a circular hole on the resinous incrustation which it lines with a thin, silken webbing and pupates within. The pupa, when taken out of the cocoon, is brick brown in colour with a slight bloom. It is 3 mm. long and a little over a mm. broad, the two black spots on the head represent the eyes. There are a few short hairs at the posterior end (Plate XXVII, fig. b). The adult is pale brown. When resting on the lac-covered sticks it rests at an angle, the anterior part of the body being slightly raised. The moths are not very brisk fliers. They have hitherto been observed to be quiet during the greater part of the day (Plate XXVII, fig. c.). The moth has also been reared at Kandy (Ceylon) from larva in resinous masses of lac, *Tachardia albizziæ* (*Bom. Jour.*, Vol. XVI, p. 607, 1905).

Besides these, two other tiny moths. *Oedematopoda venusta*, Meyr., *Exot. Micr., I, p. 97, Aug. 1913*, has been bred from colonies of *Tachardia lacca* at Jabalpur, C. P. and *Oedematopoda cypris*, Meyr., *Bom. Jour.*, XVI, p. 608, 1905, Kandy, Ceylon, has been bred from colonies of *Tachardia albizziæ* on *Theobroma cacao*. An Anthocorid bug *Triphleps* sp. has also been noted to affect the gravid lac females at Bangalore in South India.

I (b) Parasites. The damage that is done to brood-lac by caterpillars is partially seen, but the loss that is annually caused by the little parasites belonging to Ichneumonidæ, Braconidæ and Chalcididæ is very great. The study of these parasites is extremely fragmentary and the exact role played by them in the economy of lac cultivation is still undetermined. Anyone who has followed critically the development of the lac insect must have been struck at particular times with the abnormal

PLATE XXVIII.





presence of the parasites which insidiously lay a heavy toll of life. In particular seasons the loss is so great that a good portion of the brood-lac is utterly destroyed or rendered unfit for propagation purposes. These parasites are especially abundant in August, September and February-April. An examination of the *ber* brood-lac at Pusa during February and March 1922 revealed the fact that more than half the females were parasitized (Figs. 31—32). When the female cells were teased open,

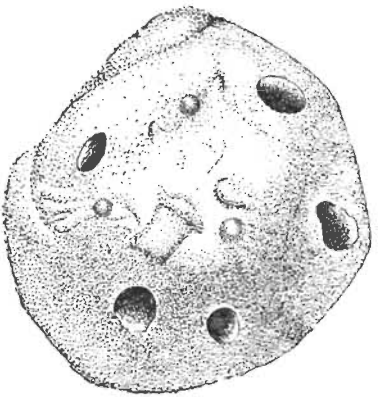


FIG. 31. Exit holes of *Chalcidida* parasites from a female test. × 30. (Original.)

pinkish white grubs were found (Plate XXVIII a) in them. From these, adult *Braconidæ* (Plate XXVIII b) emerged, which are to be seen hovering round the encrusted branches. The number of *Chalcid* parasites is far in excess of either the *Ichneumonidæ* or the *Braconidæ*. *Tachardiæphagus thoracicus*, Gir., heavily parasitizes *babul* lac in Sind, as well as lac in Ceylon. *Lissencyrtus troupi*, Cam. is an important parasite of *Laccifer lacca* on *ber* in Bengal and the Chhota Nagpur Plateau. In some years it is so bad that more than half the females are found parasitized. Unlike *E. amabilis* the presence of the parasite is not easily seen. The eggs are laid into the female through the tubercular opening. The developing grubs remaining feeding on the body juices of the female and when

full-fed pupate within the host (Fig. 32-1). They come out by making holes on the resinous test. (Fig. 31) other *Chalcididæ*, such as—

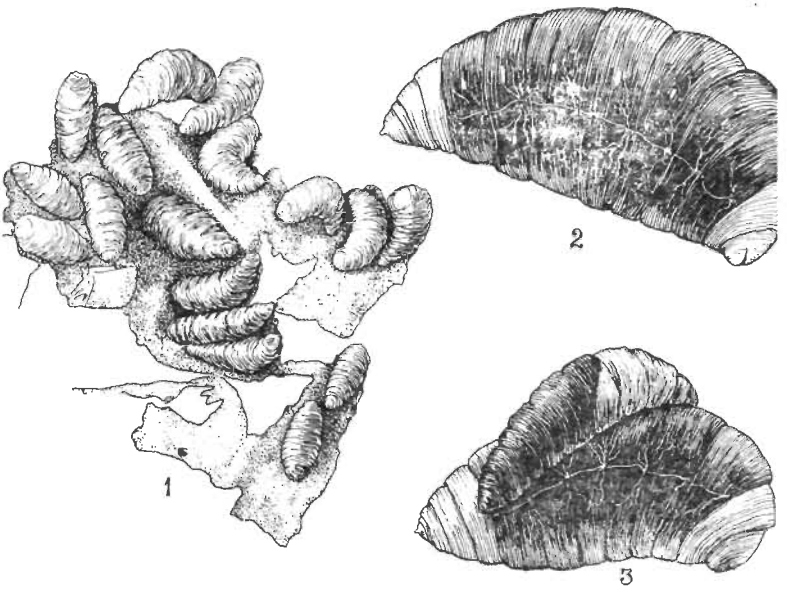


FIG. 32. 1. A lac female dissected to show the position of seventeen *Chalcid* grubs within its body . . . . . much enlarged.
2. A *Chalcid* grub . . . . Lateral view . . . much enlarged.
3. A *Chalcid* grub with a parasitic grub on it. Lateral view . much enlarged. (*Original.*)

Coccophagus tschirchii, Mahdihasan.
Elasmus claripennis, Cam.
=*Cyclopleura claripennis*, Cam.
=*Elasmus colemani*, Mahd.
Tetrastichus purpureus, Cam.
=*Hadrothrix purpurea*, Cam.
=*Tetrastichus immsii*, Mahd.

lay a heavy toll yearly. The above parasites were reared from actually dissected specimens of *Laccifer lacca* on *ber* and *palas*. In some cases,

Chalcid grubs were themselves found parasitized by other *Chalcid* grubs (Fig. 32, 2). The study of the parasites and hyperparasites requires critical study and unless this is done, nothing definite can be recommended to check their ravages.

II. Frost, forest fires and hot winds. Much damage is also done to the crop on the trees by frost, forest fires and hot winds. If the fall of frost synchronizes with the emergence of the males, large numbers of them are killed off without fertilizing the females. When fires break out in forests considerable damage is done to the crop on the trees. The only way to check the inoculated trees from being damaged is to make clearings and to plough up the ground round them. The hot winds generally begin to blow from the middle of April to the end of May when the crop, if exposed, is seriously damaged. The body contents of the female insects dry up and in consequence the female dies. This is apparent by the pitting up of the resinous cells in the centre. The colour too, of the cells affected with hot winds, changes. They become translucent, pale brown, with the shrivelled up body of the female in the centre. In some cases, when the hot winds continue to blow for a number of days at a stretch, the resin melts and drops down on the ground, leaving the dead females sticking up on the branches of trees. If the trees are in the open nothing can be done to check the crop on them from being affected with hot winds. But in any new scheme of starting fresh plantation for the cultivation of lac, much could be done to lessen the effect of hot winds by planting a fringe of trees—preferably *mahua* (*Bassia latifolia*), *karanj* (*Pongamia glabra*), *babul* (*Acacia arabica*) or *akasi neem* (*Mellingtonia hortensis*) to act as buffers to break the force of the winds.

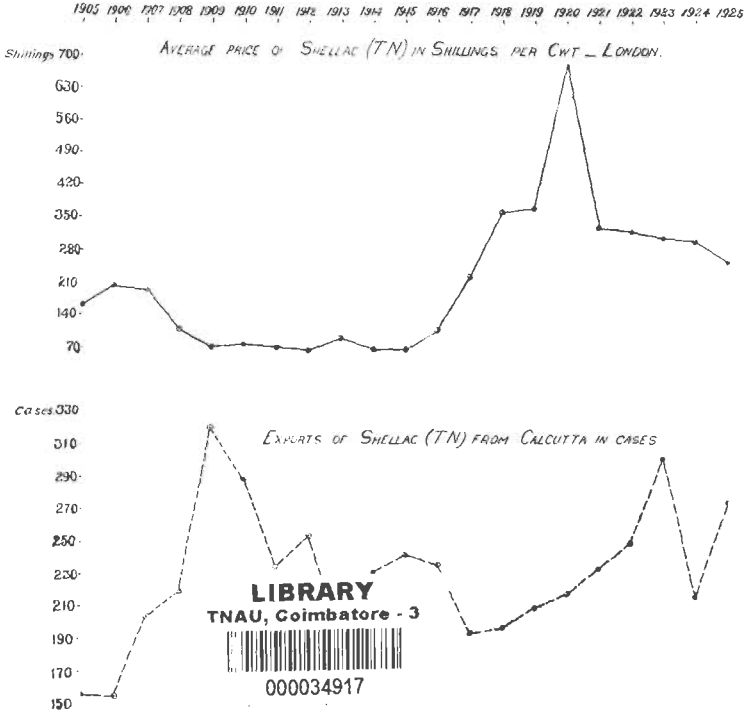
III. Other factors. In localities where lac cultivation is a paying industry, many thefts are committed and much traffic goes on in illicit collections. The proximity of a village *Bania*, or *Bepari* as he styles himself, is an indication of the possibility of an illicit trade being carried on and if a sharp eye is kept on him, much can be done to mitigate the evil. Some of the jungle tribes are especially troublesome. They lead a nomadic life and generally move about at night. They have been known to cover from 20 to 30 miles during the night, remove the crop from the trees and to return to their temporary quarters before day-break. Much could be done to reduce their activities by employing them as watchmen or giving them the lease of trees at a nominal cost.

Recommendations for the extension of lac cultivation.

I. Issue of forecasts. Unlike other industries, the lac industry suffers much from violent market fluctuations in the prices of shellac

in the consuming countries (Chart 2). The reasons which bring about such changes are still not definitely known. When the prices fall, as

Chart 2



was the case before the war, the cultivators, as well as the lease-holders, give up collecting lac from the trees with the consequence that the predators and the parasites increase abnormally and the subsequent productions are poor in quantity as well as quality. With the shortness

of the crop, the prices of shellac again rise and there is a general scramble to benefit by the increased rates as far as possible. But the required quantity of stick-lac is not obtainable. Efforts are then made to start cultivation in old localities, but it takes time to restore the equilibrium. It is thus essential to stabilize the rates of shellac, as far as possible, but this is not an easy task and far beyond the capacity of any individual or a society. Much could, however, be done by the issue of reliable forecasts based on some definite data. These will allay the anxiety and uncertainty that is at present created by the issue of unreliable reports circulated by interested persons.

II. Manufacture of unadulterated shellac. Secondly, the manufacturers should, as far as possible, put down the practice of adulterating stick-lac as well as shellac. If any adulterated material is brought by the cultivators for sale, it should be discarded and if the cultivators of a particular locality persist in this malpractice, they should be banned from marketing their produce. The manufacturers should themselves make honest efforts to manufacture only unadulterated shellac. The foreign consumers are at times put to great inconvenience by not having standard shellac to use for their particular requirements. If they can be assured of a regular supply of a uniform product, they begin to use more of it for their other requirements as well. People who have been in the trade for many years inform me that, if this were done conscientiously, the consumption of shellac would increase enormously.

III. Payment of fair prices to the cultivators. Along with the standardization of shellac, the manufacturers should, through their *Beparis*, *Arahtiyas* and *Gomashtas*, arrange for the payment of fair prices based on a sliding scale on the prices of shellac in the Calcutta market to the cultivators in the interior. These people are very often duped by the itinerant, petty *Beparis* who use false weights and make their purchases generally on the basis of *beuli*. These people generally charge from 15 to 20 per cent. more in weight and thus rob the cultivator of his proper dues. I have known cases personally, where the cultivator was paid only Rs. 22 per maund, whilst shellac quotations were from Rs. 182 to Rs. 185 per maund in Calcutta. The fair price to be paid in that case should have been from Rs. 70 to Rs. 75 per maund of 82 lb. Had the cultivator been paid this price, he would have got an extra incentive to increase his cultivation and thereby to produce more stick-lac. The present inflated prices of shellac do not augur well for the industry. I think the prices of shellac should range from Rs. 80 to Rs. 100 per maund and accordingly the price of stick-lac should vary from Rs. 30 to Rs. 40 per maund according to the quality of the material.

This will amply compensate the growers, will leave sufficient margin to the manufacturers and will finally lead to the greater utilization of shellac.

IV. The establishment of nurseries is essential in any scheme of extension of lac cultivation. Without opening up new areas where success may be doubtful, if nurseries are established in the area already mentioned before (p. 37) the production of stick-lac could easily be doubled. When prices of shellac are high, it is difficult, if not impossible, to secure brood-lac in bulk for purposes of extension of cultivation. The cultivators are loath to part with their brood-lac and ask exorbitant rates. When shellac was at Rs. 182 a maund in Calcutta as much as Rs. 120 a maund was asked for a maund of *palas* brood-lac. This is not only exorbitant but fatal to the extension of cultivation. It is, therefore, extremely desirable that nurseries should be started in the area referred to above, and the prices of brood-lac should be adjusted on the basis of prices of shellac in Calcutta. If the Zemindars and others, owning fairly good forests stocked with either *palas* or *kusum*, could be induced to confine their attention to this aspect of the industry, a time would come when brood-lac would be readily available in quantities and at fair prices.

V. Collection of *phunki* lac only. The early history of the lac industry shows that lac was used for the colouring matter which it contained, when prices of cochineal, for which it was used instead, went high. Later on, when the qualities of resin came to be known, the use of the lac-dye fell off. But still it remained a marketable commodity and fetched some price. In fact, it represented the manufacturer's gain from a by-product. But with the introduction of German synthetic colours, it rapidly fell into disuse. At present it could be had from Rs. 3 to Rs. 4 a maund. The cultivators, before the advent of synthetic colours, used to collect lac before swarming took place so as to have the maximum of colouring matter in the material, with the result that the healthiest and most virile of the specimens were killed off from year to year. This process has been in practice for the last fifty to sixty years and it is a wonder how the industry has survived such a drastic treatment. But, as every biologist would tell you, it is only the prolific fecundity of the insect that has survived the rigorous treatment meted out to it. Now that lac-dye is of no commercial importance, it is proper that steps should be taken now to regenerate the insect and to resuscitate the industry on sound economic lines. As a first step towards the attainment of this object, the manufacturers should only buy *phunki* lac. Material collected before swarming should not be purchased at all. This would lead to the production of large stocks of brood-lac wherewith

to extend the cultivation and to lessen the cost of production. Within a decade of the adoption of this measure, more stick-lac will come to the market for sale and the prices of shellac would automatically adjust themselves according to the stocks of stick-lac available each year.

VI. Modifications in the terms of lease to *Thikadars* or contractors. The terms of lease given to *Thikadars* should be more liberal than is the case at present. They should be given lease of the forest for such period as would enable them to make a fair profit and to improve the estate. As a condition, they should be asked to collect all brood-lac from trees during a season, and to use it for inoculating other trees within the terms of lease. This would prevent multiplication of the parasites and predators. They should also be asked to stipulate to the inoculation of a fairly good proportion of trees under their charge so as to increase the supply of brood-lac. They should be asked to collect brood-lac a fortnight before the local date of emergence of lac insects and to utilize it for putting on to other trees within their charge.

VII. Extension of lac cultivation on co-operative scale as a cottage industry. The cultivation of lac is eminently suited as a cottage industry. As has already been stated above, no very costly instruments or paraphernalia are required to carry on the work. The main lac tract in the country comprises of a part of Bengal, Bihar, the Central Provinces, and if a line were drawn from Malda to Gaya, Mirzapur, Jhansi, Hoshangabad, Akola, Chanda, Jagdalpur, Parvatipuram, Hindol, Bankura and Rampur-Hât, this will represent the main lac-growing tract where lac is either being grown now or where there are facilities for the introduction of lac cultivation. This does not of course comprise the outlying tracts of Assam and Sind where the host plants are *Ficus* spp. and *Cajanus* sp. in the former and *Acacia arabica* in the latter. Within the area roughly outlined above, there are parts which are especially suited for the extension of the lac cultivation. If in this area serious attempts are made now, on a co-operative scale, to stock it with lac host trees, a time will soon come when sufficient quantities of lac will be produced which will remove the possibility of the introduction of the synthetic or wacker lac from ousting the natural product from the world markets. The Director General of Commercial Intelligence, Calcutta, very aptly remarks :—

***"The use of synthetic lacquers, though growing in importance, has not yet appreciably affected the trade in Indian shellac. The enormous increase in the demand for automobiles and for nitro-cellulose lacquers (which use a small amount of natural shellac) has helped to maintain the demand for shellac.

As shellac has advantages over synthetic lacquers, the best way to meet the competition appears to be to increase production and lower the prices."*

If intensive work on co-operative lines is carried on in the Jangipur Sub-Division of Bengal, the Sonthal Parganas and the Kolhan in Bihar and Orissa on *ber*; in Palamau, Rewa, Hoshangabad and Gondia on *palas*: Ranchi-Chybassa, Dhamtari and Kanker on *kusum*; increasing quantities of lac would be put on the market to stabilize prices and to prevent violent fluctuations. If a cultivator has ten to twelve *ber* trees round about his homestead, he can easily prune them in time, utilize his own brood-lac or obtain it in exchange from his neighbours. All that he requires are one or two pruning knives, which he has always with him, and a few *seers* of brood-lac. The care of the *ber* trees, the pruning and the scraping of lac could be done by the members of his family. The sticks from which lac has been scraped off could either be used for fencing or for fuel. In putting down plantations on a large scale, supervision charges increase, and if any pest happens to establish itself in the plantation the cost of exterminating or bringing it under control increases. Hitherto, I have not seen any plantation on a large scale which is a financial success. If an accurate statement of charges incurred in setting up the plantation for purposes of lac-growing is kept, it will be found that it is not a financial success. In one or two *ber* plantations on a large scale I have seen *Phytoptipalpus transitans*, Ewing, so bad that the young trees suffered seriously from its presence. The individual cultivator is able to pay more attention to a limited number of trees than is possible in a large plantation. If, however, *ber* trees are planted on field embankments, as is the case in the Jungipur Sub-Division of the Berhampore District, Bengal, they receive cultural treatment which is beneficial to them. Of course, the system adopted in this tract is not of universal adoption in the country, but where similar conditions prevail, it will be found that the cultivators earn enough as a subsidiary income to meet the rental demands and to reserve the crop for the use of their family. The question of the supply of healthy brood-lac at reasonable rates could also be arranged if the whole thing is managed on a real co-operative basis so as to increase the cultivation, and to utilize the poor soil to some useful purpose. Hitherto, there has been no cultivation in the proper sense of the term. All that has been done hitherto is collection only. If, however, regular cultivation on block system is started now, the area under cultivation would increase, the cost of cultivation would be reduced and

* Review of the Trade of India in 1926-27, p. 90.

the dangers of theft would be minimized. *Ber* is a very hardy plant and grows well even in poor soils. The only trouble with it is that it requires some care in the beginning to establish it. But when once the trees have established themselves well, very little care is required subsequently. Even seedlings three to four feet high have a long tap-root and as such could only be transplanted with some difficulty. It is, therefore, easier to raise the seedlings in a nursery and thereafter to transplant them twenty-four to thirty feet each way. The only after treatment required is to occasionally hoe up the soil below trees. *Palas* could be easily raised from seeds either broadcasted in the beginning of the rains, or the seeds dibbled in at regular distances during the rains, the gaps in the plantation being filled up with seedlings from the nursery. The plants, when well established, could be thinned out gradually, until seven to ten years after planting they are twenty feet apart each way and are fit to be inoculated. If, however, the soil between the rows is fairly firm in texture, a catch crop of millets or *bajri* (*Pennisetum typhoideum*), or *arhar* (*Cajanus indicus*), or *khorasani* (*Guizotia abyssinica*) could be raised to meet a part of the cost of establishing the plantation. The area should however be divided into three blocks or coupes so that with a well adjusted system of rotation, plants in each coupe would get rest. If possible, sufficient space should be left between the coupes so as to plant *mahua* (*Bassia latifolia*), *karanj* (*Pongamia glabra*), *babul* (*Acacia arabica*) or other fast growing trees to protect the trees in the plantation from being affected with hot winds. *Mahua* has been called the motor tree of India and could be utilized for the production of cheap motor spirit when well established ; the other two, *karanj* and *babul*, could be used for fuel, as is the case in Berar in the Central Provinces.

The *kusum* tree grows well in clayey soils, preferably by the side of *nallahs* or mountain streams in the interior of forests. It is raised from seed which is first sown in nurseries. When the seedlings are two to three feet high they are to be planted out permanently. As the seedlings are tender, great care is necessary in the beginning. When the seedlings are well established no more care is necessary than that of occasionally stirring up the soil near the roots. The tree grows slowly and becomes fit for inoculation fifteen to twenty years after being planted out. Its timber is good and it yields an oil which is used for burning or for the manufacture of cheap soap.

VIII. Exchange of brood-lac. When brood-lac on the same food-plant and in the same locality is used for purposes of propagation for a number of years, it degenerates and requires to be changed. In doing so, care should be taken to obtain brood-lac from such localities where

the climatic and soil conditions are very much like those obtaining in the locality where it is intended to be introduced. Only healthy brood-lac, free from predators and parasites, should be used for purposes of propagation. For the time being *ber* brood-lac should be put on *ber palas* brood-lac on *palas*, and *kusum* brood-lac on *kusum* and *palas*. In the Central Provinces *kusum* brood-lac when put on *palas* has spread well and in the Bankura District in West Bengal the lac cultivators put *palas* brood-lac on *ber*, but not *ber* brood-lac on *palas*.

APPENDICES.

APPEN

* *Names of trees on which lac can be grown,*

Name used in the Bulletin	Botanical name	Bengal	Assam	United Provinces
Ber . . .	*Zizyphus jujuba*, Lam.	Kūl, Bor, Bor.	..	Ber, Beri .
Bar or Bargad .	*Ficus bengalensis*, Linn.	Bar, But .	Ranket (Garo). Bot.	Bargad, Bar, Bargat.
Babul . . .	*Acacia arabica*, Willd.	Babul, Kikar, Gabur Bābla.	..	Babul, Babur .
Husum . .	*Schleichera trijuga*, Willd.	Kusum Kosamo.		Kosum, Gausam, Kusum.
Palas . . .	*Butea frondosa*, Roxb.	Palas, Parus-Paras (Bihar).	Laho Kung (Lepcha).	Dhāk, Palas, Tesu, Kankrai, Chichra.
Pakur . .	*Ficus infectoria*, Willd.	Pākar, Pakur.	Prab (Garo), Kangji (Lepcha).	Pakhār, Pakri, Khabar, Pakur, Pelkhan.
Pipal . . .	*Ficus religiosa*, Linn.	Aswat, Asūd, Asvattha.	Bor-bur (Cachar).	Pipal . .
Siris . . .	*Albizzia lebbek*, Benth.	Sirisha, Siris	..	Siris, Sirin, Sirai.
Arhar . .	*Cajanus indicus*, Spreng.	Arhar, Oror, Orol.	Mirimah, Garo-mah.	Arhar, Tuar .
Gular . .	*Ficus glomerata*, Roxb.	Jagya Dumar, Yajna Dumar.	Tchoagtay (Lepcha).	Gular, Umrai, Paros, Umar.
Ghunt Ber . .	*Zizyphus Xylopyra.*	..	..	Kat-ber, Ghont Ghunt.
Jalia . . .	*Shorea talura*	..	..	..

* Watt, G. *The Dictionary of Economic Products of India.*

DIX A.

with their botanical and provincial equivalents.

Punjab	Central Provinces	Bombay	Madras
Ber, Beri . .	Bher, Bori, Ringa (Gond).	Ber, Jangri (Sind), Ber, Bhor, Bordi, Bór, Bóra.	Elāndap, Yellande, Elladu, Régu, Ganga Regu, Yalachi, Yagachi.
Bera, Bor, Bohir, Bargad.	Bar, Barghat, Barelli (Gond).	War and Bur (Sind), Wad, Vad, Barghat, Vada.	Ala Mari, Peddi Mari, Ala Peralu.
Vabhula, Barbara	Babul . .	Bāval (Guj) Bahbula, Kali Kikar (Sind).	Tūma, Nellatuma, *Gobli, Karrijali.*
Samma, Jamoa, *Gausam*, Kussum.	Kusum, Kojba .	Peduman, Kosam, *Kosamb*, Kocham, Koshimb.	Pāvā, Pūlachi, Puma-*rum*, Puvu, Pusku, Rostanga, Posuku.
Palas . . .	Chiulha, Pala .	Palāa, Khākāra, Khakharo, Tesu-ka-Jhar, Khak-hado, Khakhar-nu-Jhada, Paras, Phalāsa-cha-Jhada.	Porasan, Parasa, Purasbu, Puraishu, Palasham, Móduga, Mohtu, Palādulu, Muttuga, Thoraa, Muttaga-a-Marā.
War, Palkhi, Bathar, Pipli, Pakri.	Serilli (Gond), Pakri.	Pepar, Pipli, Pakri, Gandhaum-b a r a, Pepri.	Pepre, Kurku, Jooi, Jewi, Yuri, Kari.
Pipal, Bhor . .	Pipal . .	Pipur, (Sind), Pim-pal, Piplo, Pimpala.	Arasa, Aswartham, Rai, Raiga Rāvi.
Siris, Siras, Sirin	Siris, Saras .	Sirus (Sind), Chicho-la, Mathā Siras, Pelo-sarshio.	Vaghe, Kot Vaghe, Darshan.
Arhar, Dinger, Tohar.	Arhar, Tur . .	Tuvero, Túar, Tuver, Turi.	Thovarey, Tuvarai Kandalu, Togari.
K a t h g u l a r, Rumbal, Batbar, Palāk. Dadhuri.	Umbar-gular .	Umbar, Umbara, Atti, Rumadi.	Atti, Moydi, Bodda Paidi.
..	Katber, Ghota, Ghoudi Ghunt-ber.	Kankoe, Ghot, Suti, Bhorgoti, Kando Gossi, Guti.	Goti, Gotte, Challe, Mullu Kare.
..	..	..	Taluva, talavi, Jalari Jalavanda, Jalada.

APPENDIX B.

Terms used in the lac trade.

Atta	Cotton-wool or fibre of *madar* (*Calotropis gigantea*) soaked in concentrated lac-dye. These are generally used by Hindu women in Bengal, the United Provinces, the Punjab and parts of the Central Provinces for colouring the soles of their feet.
Anti	A branch of tree 8 inches to 11 inches long covered with brood-lac. Fifty such sticks form a bundle known as *Tudi* or *Tura*.
Arahtiya	Commission agent. *Thikadars*, as well as other petty collectors, bring their collections for disposal to *Arahtiyas*, who either sell the stuff on commission or buy it for themselves.
Bahilwaya	Is the *Karigar's* assistant. It is his business to stretch the Pagh or Pag with palm-leaf on the porcelain cylinder, and ultimately to draw it out into a thin sheet, known as shellac.
Batta	Refraction on resinous lac. The trade generally allows a refraction of 1 to 2 per cent. rosin. Over and above this, *Batta* is charged.
Beuli lac	Lac free from dust, pieces of stick, or other adulterants.
Bhatta or Bhatha	Open oven in which charcoal is burnt and before which a portion of the cloth-bag, containing seedlac, is exposed.
Bhusi	Pieces of stick-lac, etc., obtained by washing stick-lac with water. It is usually used in the furnace for reclaiming Passeva.
Button lac	A fine grade of shellac, melted and spread into small circular thick discs on plantain stems. This contains neither orpiment nor rosin and, as such is much used for various purposes where colour is not the object.
Chapra	Shellac.
Chowrie	Seedlac.
Dandi	Twisted ropes containing shellac. When these are boiled down in big cauldrons, with an alkali, the shellac adhering to the cloth-bag floats on the surface. It is then skimmed out and pressed into thick, flat cakes 12 inches to 14 inches in diameter.
Dongi	Flat pieces of stone in front of the oven on which melted lac from the cloth-bag oozes out and falls down.
Dust lac	See *motamma*.
Fine orange	A grade of shellac. It is fine, golden yellow in colour.
Ganthi	Knots, accumulation of dirt, etc., in the sheet lac.
Garnet lac	A grade of shellac made from small, granular seedlac. Sheets or pieces are generally one-tenth of an inch thick. It is mostly dark-red in colour.
Gomashta	Is the under-broker to the manufacturer. It is his business to keep his chief informed of the market conditions of his place.

Kanja	Powdered stick-lac.
Karchhola	An instrument to stir up fire in the oven.
Karigar	Is the chief worker, who sits near the oven and holds the cloth-bag at one end, whilst the other is slowly turned round by a woman, boy or girl.
Khadowla	Fine dust obtained by sifting washed seedlac.
Kham lac	Stick-lac.
Khud or Garda	Fine dust obtained by sifting ground stick-lac before washing it with water.
Kiri	The residue left within the cloth-bag after the melted portion has been turned into shellac. It is taken out of the bag by the *Karigar* with a *Kiri-Khudna* and, while hot, is turned into circular, flat cakes. These are used locally for bangle-making, etc.
Kiri-Khudna	Is an instrument with which the *Karigar* takes out the hot *Kiri* from the cloth-bag.
Lac-dye	Is the colouring matter obtained by washing stick-lac with water. The colour is run into large vats where it is allowed to settle. The supernatant water is then drawn off through a series of graduated plugs and the thick, crimson pulp consisting of chitin, visceral contents of dead lac females, wax, and dirt is put under presses and then cut out into small, circular pieces or turned into large, flat cakes.
Lakhdana	Seedlac.
Livery leaf	A grade of shellac.
Molamma	Fine dust obtained by separating the washed seedlac. It is generally mixed with khud for making bracelets, etc.
Morha	A twig covered with lac.
Nagli or Nagoli	*Kusum* stick-lac.
Neera	Palm-leaf 18 inches to 2 feet long, 3 to 4 inches broad, used by the *Bahilwaya* for spreading out Pag or Pagh on the porcelain cylinder.
Orange leaf	A grade of medium quality of shellac.
Pag or Pagh	Melted shellac that oozes out of the cloth-bag and falls on the stone slabs in front of the oven. It is worked up into proper consistency by the *Karigar*.
Pank	Is the refuse collected on the cloth in straining lac-dye.
Panna	Melted lac drawn out into a sheet by a *Bahilwaya*.
Passeva	Is the residual matter left in the bag. This is obtained by boiling the rope-like twisted bags in big iron cauldrons containing an alkali. Sometimes the twisted bags are soaked in tanks containing methylated spirit. The resinous portion is taken out and pressed flat into flat round cakes 8 to 12 inches in diameter and $\frac{1}{8}$ to $\frac{3}{4}$ inches thick.
Pathri	A thick piece of stone with a cavity in the centre for holding water. It remains close to the *Karigar*.
Pnip	Porcelain cylinder closed at one end and open at the other. It is filled with hot water and is placed at an angle by the side of the oven close to where the *Karigar* sits.
Peri	Is that portion of the cloth-bag which is immediately in front of the fire in the oven.

Perbanda	A stout iron spatula with which the *Karigar* scrapes the melted lac from the cloth-bag and cooks it in front of the fire in the oven.
Phirki or Charkhi . . .	Is a revolving wooden disc with four short blades attached to one end of the bag. It is usually worked by a woman, boy or girl.
Phunki or Phungi lac . .	Sticklac collected after the emergence of young insects.
Rangeen	Palas stick-lac, so called on account of its containing a large quantity of colouring matter.
Seedlac	Is lac obtained by soaking and washing ground stick-lac with water.
Shellac	Seed-lac mixed with rosin and orpiment, cooked and drawn into thin sheets. Superior grades are beautiful pale orange in colour. The colour and texture depends upon the variety of stick-lac from which it is manufactured.
Sita	Lac cells from which the young insects have swarmed out.
Stick-lac	Lac collected either before or after the emergence of young insects.
T. N.	A grade of shellac containing 2 to 3 per cent. of rosin. It is also manufactured pure without any rosin or orpiment according to trade requirements.
Tongue lac	A special grade of shellac made from transparent pale yellow twisted flakes of rosin on female cells. It is usually made in the form of lustrous fine threads.

APPENDIX C.

Fumigation of stick-lac before storage.

(From "Indian Insect Pests.")

The best method of preservation is to fumigate the stick-lac and then to store it in insect-proof bins or jars or boxes. Fumigation is the process of exposing the scraped lac to the fumes of carbon bisulphide at a proper strength for a definite period. Stick-lac exposed to the fumes of carbon bisulphide at the rate of 1 oz. per 10 cubic feet of space for 12 hours will be freed from the injurious caterpillars that spoil the rosin. When large quantities are to be fumigated carbon bisulphide at the rate of one to one and a half pound per ton (27 maunds) may be used. Before pouring in the carbon bisulphide all the doors must be made air-tight. After 24 hours the fumigated stick-lac is to be taken out and aërated with a piece of muslin over it to prevent moths from again laying eggs on the fumigated material.

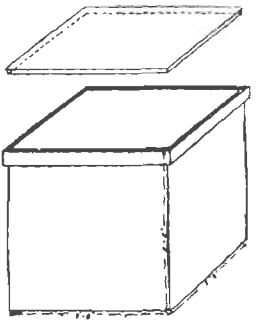


FIG. 33. The fumigating-box.

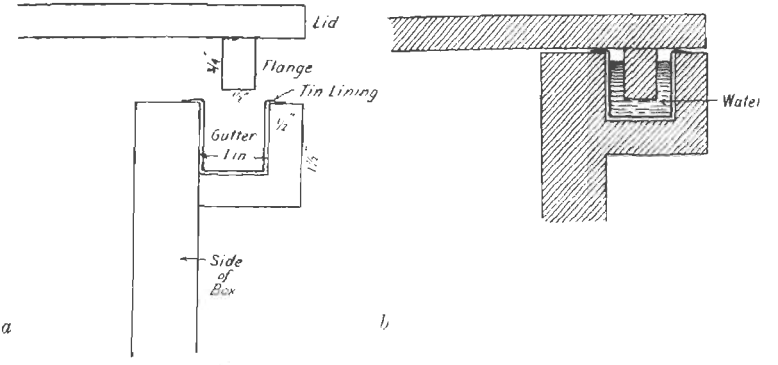


FIG. 34. Details showing construction of the fumigating-box.

(*a*) Tin-lined gutter and the flange.
(*b*) The lid in position with water in the gutter.

As carbon bisulphide is extremely inflammable and unpleasant to handle, the following precautions must be taken :—

(1) Keep the carbon bisulphide in stoppered (not corked) bottles under lock and key.
(2) While fumigation is going on, nobody is to be allowed to go into the room.
(3) No lights, lighted pipes or cigarettes or any form of fire must be brought near the fumigating room.
(4) If the smell of carbon bisulphide be noticed, no one should be allowed to go near with a light.
(5) Do not place a bottle of carbon bisulphide in the sunlight or in any place where it will become hot.
(6) Never take a bottle of carbon bisulphide near a fire or lighted lamp.

The above could best be used for fumigating small quantities of stick-lac (Figs. 33—34). Where large quantities have to be dealt with, fumigation with HCN-Hydrocyanic acid in specially built chambers (Fig. 35) or moveable boxes or tents will have to be done. In the pucca fumigatorium at Pusa which has been used for the last twenty-three years for fumigating quantities of grain, etc., in bulk, the material to be fumigated is piled in bags inside the room. When full the iron-door is made air-tight with *putty*. It is then charged by pouring the acid through a tube on the top and the gas allowed to act for twenty-four hours. The door is then opened and the fumigated material is allowed to aërate for another twenty-four hours when it is removed.

FIG. 35. A fumigatorium to fumigate stick-lac in bulk, Pusa. (Original.)

APPENDIX D.

Some useful formulæ.

Many enquiries have been made in the past about the use of small quantities of lac produced locally and which have no marketable value. These may be utilized in preparing varnishes and polishes for home use. Two simple formulæ are given below, but before being used for this purpose the material should be washed according to the instructions on page 80.

I.—*Formula for making spirit varnish.*

Methylated spirit	10 oz.	(25 tolas).
White rosin (Pine)	1 oz.	(2½ tolas).
Seed-lac		(2½ tolas).
Dragon's Blood	⅛ oz.	(4 mashas).

[Vernacular: ***Kan Kharaba, Ajrāng, Birādukhi*** (Hindi.]

II.—*Formula for making French Polish.*

Seed-lac (ground fine)	3 oz.	(7½ tolas).
Methylated spirit	20 oz.	(50 tolas).
Boiled linseed oil	*a little.*	


N. W. FRONTIER
PUNJ
BAHAWALP
RAJP
Mirpurkhas
Umarkot
Omarsadho
GUJARAT